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THE SAULT STE. MARIE CANAL.

ONE of the most remarkable structures in the world of its kind, and the most remarkable of all, considered with reference to the amount of business that it is capable of carrying and actually does carry, is the Sault Ste. Marie canal, in the State of Michigan, which connects Lake Superior with Lake Huron, and is in point of fact the connecting link between the great navigations of the United States and those of Canada. This canal is at the present time a matter of unusual interest in England for two reasons—the first being that it will come up for consideration at the congress on inland navigations which is fixed to take place at Manchester at the end of the present month; the second, because it is on the programme for a special visit from the members of the Iron and Steel Institute, on the occasion of the forthcoming visit to the United States.

For these and other reasons, a short description of the canal is likely to be of interest.

The St. Mary's Falls canal was constructed in 1855 for the purpose of enabling the traffic by water between Lakes Superior and Huron to overcome a fall of 20 ft. 4 in. in the St. Mary's Strait, which is the connecting waterway between these important lakes. The river of St. Mary has a tortuous course, and at the Sault there is a fall of 18 ft. 2 in., which renders navigation unsafe without a connecting canal. The canal is only about a mile in length, but its traffic has increased from an annual volume of only about 100,000 tons in the year 1855, when it was constructed, to one of about 8,000,000 tons last year. The original locks on the canal were made 70 ft. in width and 350 ft. long between the gates. The vessels that then navigated the lakes were much smaller than they are nowadays, and, indeed, no ship drawing more than 11½ ft. of water could pass through the canal until 1880. In that year, however, the State of Michigan transferred the canal to the United States as a work of national importance.

Thereupon the federal government commenced the construction of a new lock, which was opened in 1881. This lock is 515 ft. long between the gates, and 80 ft. wide in the chamber. The depth of water on the sills has been increased to 17 ft., and the lift is 18 ft., varying, however, from time to time according to the fall in the rapids between the two lakes. The gates are set on parallel axes, 20 ft. apart, so that the width between the gates is reduced to 60 ft. An accumulator has been erected by the side of the lock to operate the gates and valves by hydraulic pressure, and large culverts are employed for the purpose of filling and emptying the chambers. Being placed under the miter sills, and running the whole length of the chamber, with openings at the top, arranged so as to distribute the force of the inflowing current along the center, under the keel of the ship, the filling or emptying of the chamber does not cause any disturbance of the vessel.

The initial pressure of the accumulator is about 600 lb. to the square inch, which enables the valves and gates to be worked very rapidly. The upper gates have been closed in a minute and a half, and the lock has been emptied in seven and a half minutes.

The enlargement of 1881 cost about three million dollars, but a second enlargement has been provided for since then, the estimated cost of which is about five millions more. The second enlargement embraces the construction of the largest lock in the world, with a chamber 800 ft. long between the gates, and a width both in the chamber and in the gates of 100 ft., while the depth will be 21 ft. on the sills. The depth of the canal is to be made 20 ft. throughout. It is intended to work the canal in such a way as to be able to pass a flotilla of barges through the lock with one lockage, including tug boats. This is now done on several of the more important canals of Europe, including the Aire and Calder, and of course it is regularly provided for in river transport, but the difficulty of adopting such a system in canal navigation generally is the limited size of the locks.

The old locks built in 1855 by the State of Michigan are still extant. They are now combined with lifts of 9 ft. each, designed to overcome the fall of 18 ft. in the river. The chambers are filled and emptied through the gates in the ordinary way, the gates being suspended from pillars seated on the coping of the quoins.

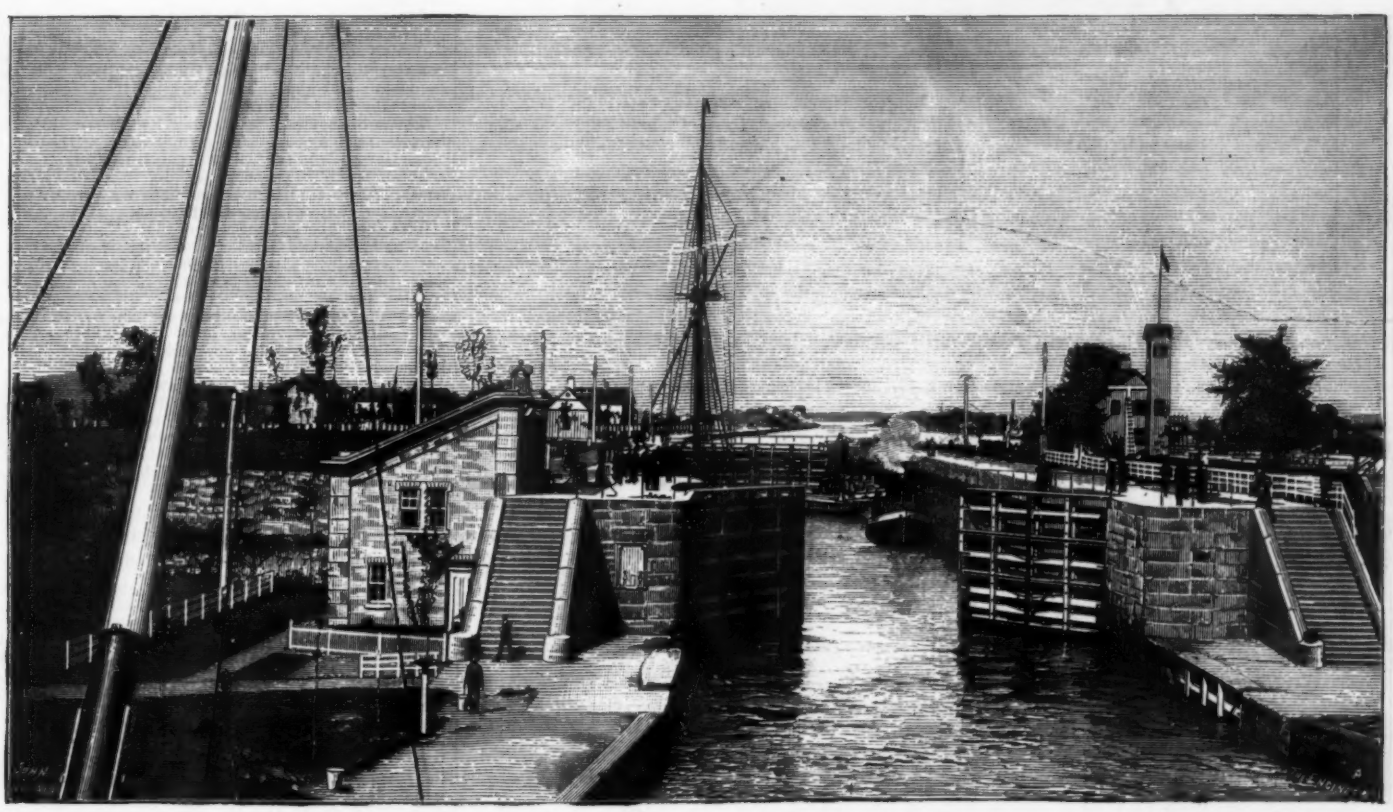
These locks, however, are now about to be removed, and superseded by the largest lock in the world, of the dimensions already stated.

The commerce that makes use of the Sault Ste. Marie canal is equally important to the United States and to Canada, and for this reason the Canadians have arranged to construct on their own side of the St. Mary's river a lock of 18 ft., with a chamber 600 ft. between the gates and 85 ft. wide. Such a work was recommended by the canal commission appointed to inquire into the subject of Canadian navigations in 1871, but it was not until 1888 that the enterprise was actually commenced.

All the shipping that makes use of the Sault Ste. Marie canal passes free of toll, whether foreign or domestic, the government of the country having recognized its importance to this extent. The canal is only, however, open about seven months of the year, as the waters are liable to be frozen over during the remainder of the period.

The freight carried is extremely various, having included in some recent years more than twenty million bushels of wheat, between three and four million tons of coal and iron ore, with iron and steel, copper, salt and other commodities. The increase of traffic within recent years has been so enormous that it may possibly be found necessary before long to construct another canal.

As it is, the traffic already represents about twelve to thirteen million tons a year, the number of vessels actually passing through the canal in about seven months having been as many as 1800. The majority of the vessels are—as might be expected—steamships, and the average cargo carried by each varies from 820 to 850 tons. Through Lake Superior, the Sault and the Erie canal, the waters of the Pacific Ocean are likely before long to be brought within 1800 miles of navigable waters flowing directly into the Atlantic Ocean. This event will be facilitated by the tunneling of the Cascade mountains in Washington Territory. It is claimed by American engineers that as New York will then be brought within 10,500 miles of Canton, while the distance between that important Chinese port and London or Liverpool is between 17,000 and 18,000 miles, New York may become the great distributing center for the produce of India, China and the East generally. Be that, however, as it may, there can be no manner of doubt that the future of the Sault canal, as the connecting link between Canada and the United States, and as the key of a navigation system extending over thousands of miles, must be one of great importance in the annals of both domestic and international commerce.—*The Engineer.*



THE SAULT STE. MARIE CANAL LOCKS, MICHIGAN.

THE BELLEVILLE CABLE RAILWAY.

THE city of Paris is constructing a cable railway between Place de la Republique and the Belleville church. As the width of Belleville Street is but 22 feet, it is possible to lay only a single track, with a certain number of shunts.

The line starts from the beginning of Faubourg-du-Temple Street and follows it throughout its entire extent, crosses the Saint Martin canal, intersects the La Villette boulevard, and then runs through Belleville Street as far as Saint Jean Baptiste church. The total length is 6,625 feet. There are 24 curves on the line, with radii varying from 70 to 4,260 feet, and gradients of as high as 7·5 per cent. The shunts, exclusive of those at the termini, are five in number. The difference of level between the termini is 207 feet.

The cable conduit is a sort of tube formed of beton, and the rails are supported by an iron frame. This system has the advantage of giving the sub-structure all the elasticity desirable in places where the track may have to support heavy transverse charges. The external rails are of the Broca type, with a spacing of 3¼ feet. They are of steel, and weigh about 33 lb. to the running foot. The middle rails, which likewise are of steel, have the form of a Z and weigh 21 lb. to the running foot. The frames or yokes that support these rails are spaced 3¼ feet apart. Each of them consists

of two principal angle irons. One of these is in the form of a V widened at the base, and supports the outer rails; the other is in the form of a U, and its branches are bent toward each other in order to receive the middle rails. These two angle irons are riveted to each other at their lower part, the opening

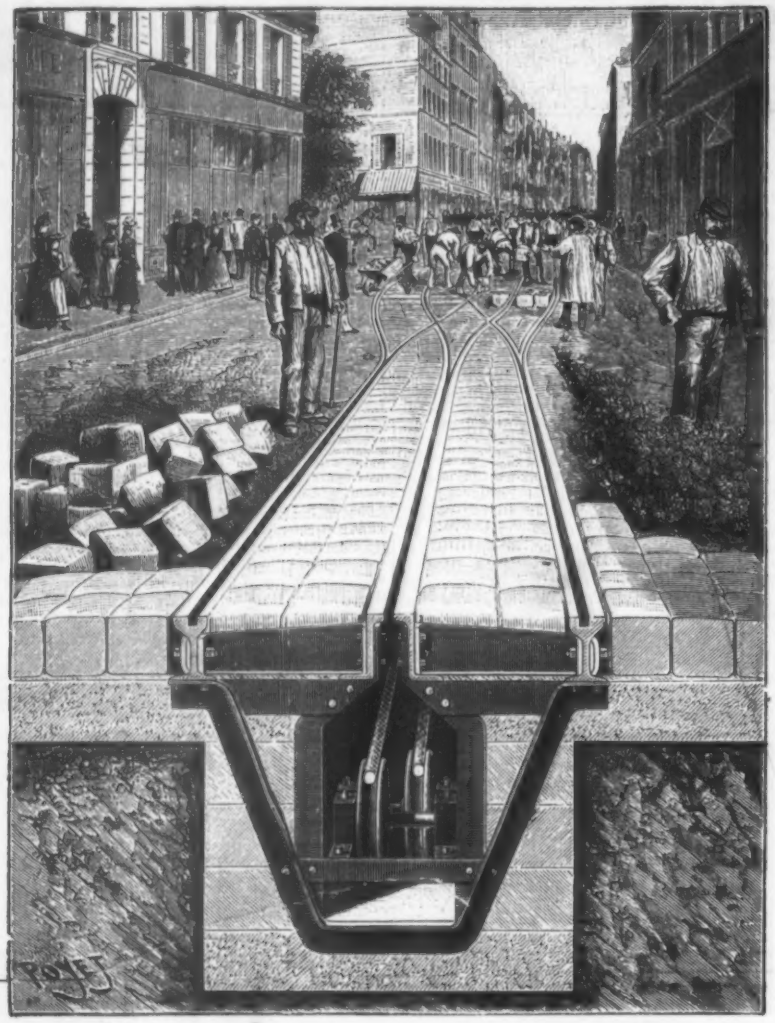


FIG. 1.—THE FIRST FRENCH CABLE RAILWAY, PARIS.

of the V corresponding to the widest part of the U. They are, in addition, united at the upper part by riveted cross pieces. Other cross pieces furnish the bearing points for the supporting and guide pulleys. The outer rails are fixed on the upper incurved branches of the V by a clamp, and both internally and externally by a clamp having a projection that fits into an aperture in the branch of the V. The central rails are bolted to the branches of the U. Their upper flanges

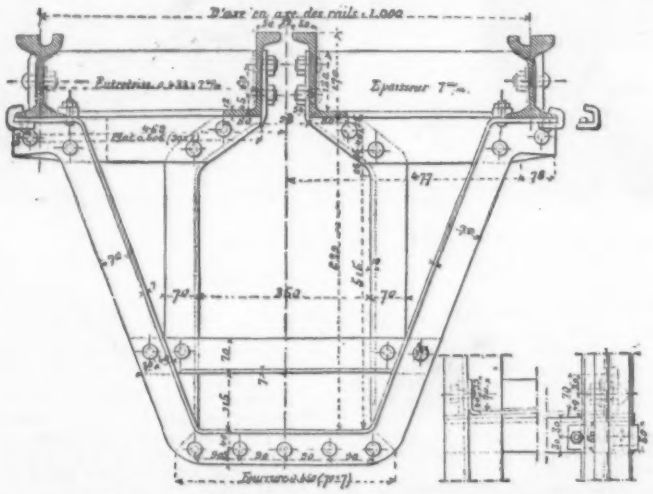


FIG. 2.—DETAILS OF THE TRACK SUPPORTS.

have a free space of $\frac{5}{16}$ of an inch between them for the passage of the grip. The four rails are cross-braced to the right of each yoke. The yokes are embedded in a masonry of Vassy cement and millstone grit, forming two vertical walls 12 inches in thickness that rest upon a bed of beton 6 inches in thickness. Over all there is a layer of beton of the same thickness, upon which the pavement is laid. The conduit thus formed is 14 inches in width and 25 in height.

Traps, three in number, distributed over the line, will permit of removing the grip from the conduit in case of accident.

The axes of the pulleys are horizontal, and rest upon angle iron frames riveted to two consecutive yokes. The pulleys have an external diameter of 12 inches, and a groove 0·16 inch in depth. They are placed at 0·25 inch to the right and left of the axis of the slot, a spacing that corresponds to that of the jaws of the grip. Their mean interval is from 32 to 36 feet.

The cable is of steel and is composed of a central and six external stands. It is 1·2 inches in diameter, 13,775 feet in length, and weighs 28,600 lb.

At each of the extremities of the line, the cable runs over large pulleys 8 feet in diameter. As it enters and leaves the depot it is inflected at right angles and runs over analogous pulleys. It is, therefore, necessary that the cars shall be able to let go of it at each extremity and in front of the depot. Let us first take the operation to be performed at the extremities—at the Belleville terminus, for example (Fig. 3). The single track, V, continues in a straight line, B, as far as to the guide pulley, P; but a diagonal, A, is detached, that is traversed by the ascending part of the cable, which afterward repasses through the track, B. Following the diagonal, A, there is a straight track, D, ending, like B, at the pulley, P. Finally, the tracks, B and D, are connected by a diagonal, C. The ascending car drops the cable when it has got a sufficient distance beyond the crossing *d*. It then runs upon the diagonal, C, and, as the ground slopes at Belleville, it descends by its own gravity to the track, B. The grip afterward seizes the cable beyond the diagonal when the car has entered upon the main track. The prolongation, B, serves as a shunt.

FIG. 3.—PLAN OF THE TRACKS.

These operations of seizing and letting go of the cable require the successive heights to be so regulated that the main curves can be effected with certainty. Now, the pulley, P, in order that it may accommodate itself to the configuration of the ground and avoid complication, must hold the cable 13 inches above the soil. As the habitual depth at which the grip seizes it is 15 inches, it is necessary that the cable at the point of seizure shall be precisely at that height in order that it may be caught by the grip. Symmetry naturally requires that it shall be the same as regards letting go. This last operation is performed as follows: The ordinary pulley situated in front of the pulley, P, supports the cable at 19 inches, its normal level underground, and its distance from the latter pulley is determined in such a way that the cable shall reach a height of 15 inches toward the point, *d*. Moreover, a pulley with an axis oblique with respect to the direction of the track swerves it to the same place, so that when the grip is opened, the cable comes out freely. For regrasping, the same conditions of height are observed, and the grasping point is in front of the diagonal, C. But, as the cable has had to be turned to the shunt track, B, in order to permit the grip to avoid the pulleys, it is necessary to bring back the grip to the grasping point at the normal distance of 2·4 inches from the axis of the slot. This effect is obtained by an unevenness of the track at the desired point.

In practice the two operations could not be perfectly performed at a single point, on account of the vibrations that the cable necessarily undergoes; but, as the jaws of the grip have a minimum opening of 2 inches and the diameter of the cable is but 1·2 inches, there will be a minimum play of $\frac{4}{5}$ of an inch, corresponding (being given the slope of the cable) to a length of 4·38 feet, sufficient to assure of the execution of the two operations.

Opposite the depot, the conditions to be fulfilled are a little more difficult, because the deflecting pulleys installed under the roadway could not, like those of the termini, be established under shelters, and had to be mounted upon inclined axes. It is consequently necessary to determine the raising by vertical pulleys.

The rolling stock will comprise 15 cars, 19½ feet in length and 5¼ feet in total width, with one interior compartment and two platforms. The first will accommodate 12 passengers, and each platform 5—22 in all. Each platform is provided with its own mechanism for maneuvering the grip.

The grip is formed of a steel plate center piece ½ an inch in thickness, bolted to the frame of the car. On each side of this piece is placed a fixed jaw to which corresponds a movable jaw, which, under the action of connecting rods and levers, is applied against the fixed jaw and grasps the cable between the cylindrical cavities. The maneuvering lever is controlled by a nut and screw. Motion is communicated to the screw by a hand wheel.

The positions of the two jaws of the same side of the center piece are symmetrical, but the reverse of each other, since they have to operate in different directions. In order to bring the cars to a full stop at all points of the line, not only will the grips be used, but also two systems of brakes, worked from each platform.—*Le Genie Civil (Abstract.)*

FABRICATION OF TWELVE-INCH MORTARS.

By A. A. FULLER and F. N. CONNET.

THE meager coast defenses of our country would seem to indicate that we, like some of the smaller European powers, depend for our safety more upon the jealousy existing between other nations than upon our own strength. While this kind of security has its worth, yet the extreme neglect we have shown in military matters not only invites attack, but smothers all inventive genius in the necessarily terrible art of war, and allows those industries to die out that would be required in the event of an unexpected conflict. It is now being realized, however, that we are dangerously near the opposite extreme from our neighbors, and in response to popular opinion Congress has made several steps to do what the old proverb enjoins "in time of peace." The prejudice properly held against offensive operations is entirely misplaced when applied to the defensive, and it is for the latter purpose that the ordnance herein described will be used.

The official designation of this type of gun is "12-inch breech-loading, rifled mortar, cast-iron body, steel hooped, 14¼ tons," and the first lot of the same for our own government includes the fulfillment of three contracts; the first, with the Builders' Iron Foundry, of Providence, R. I., calls for thirty cast iron mortar bodies, which are already completed; the second, with the Midvale Steel Co., of Nicetown, Pa., calls for thirty sets of steel hoops and mortar forgings, which are partially completed; the third, with the Builders' Iron Foundry, calls for the finishing and assembling of thirty 12-inch breech-loading mortars, which are now building. This paper will treat only of the first and third contracts.

These mortars are of the French type, with breech-loading mechanism similar to that introduced by De Bange, and, as their name implies, have cast iron bodies with two rows of steel hoops shrunk thereon. These bodies have a 12-inch bore, are 129 inches long and 31½ inches diameter, while the diameter over hoops is 41¾ inches. The "chase," or forward conical part, tapers down to 22½ inches. (See C, Fig. 1.)

The specifications in the first contract call for the casting to be made from charcoal pig and to be cast vertically, breech downward; to be cooled by the circulation of water through the core, according to the

Rodman process, so that no excessive strains shall remain: radial, tangential and longitudinal test specimens from disks, B and D, Fig. 1, cut from both muzzle and breech ends of the mortar, to have an elastic limit of about 11,000 pounds and a tensile strength between 30,000 and 37,000 pounds per square inch, or nearly double the strength of ordinary cast iron; one-fifth of the entire casting to be cut off for a shrink or sinking head, E, Fig. 1. From the disks are also to be cut two "initial stress" rings, one near the bore and the other near the exterior. The diameter of each is observed previous to its being parted off, and if initial compression be present, this diameter will increase after separation and a corresponding decrease will result from initial tension. The former is, of course, desired near the bore, and the latter near the exterior.

The metal is also tested for specific gravity and hardness; the latter is a comparative test, and is made by forcing a standard steel pyramid into the metal and noting the depth to which it sinks under constant pressure. Most of the above tests are made on the Emery testing machine, at the Watertown Arsenal.

The body is cast vertically in a pit. The flask consists of six flanged cylinders, 57 inches inside diameter, clamped together. Each of the five upper sections of the mould is three feet high, and is formed by ramming "dry sand" about a cylindrical pattern 33 inches diameter; the lower section, however, is but one foot high, and contains a cast iron pot placed in the center, around which the sand is rammed solid to a depth of 12 inches, thus forming a bottom for the mould; the rim of this pot protruding into the cavity of the mould fuses with the molten metal, seals the end of the hole made by the core, and prevents the water from penetrating the sand when turned directly into the bore after the removal of the core. This core consists of a hollow fluted column about 8¾ inches outside diameter, wrapped with ⅜ inch manila rope, covered with about ¾ inch of loam and faced with graphite; it is placed vertically in the center of the mould, and through its interior cold water is made to circulate.

The metal is melted in what is known as an air furnace, which is a structure resembling the reverberatory furnace in its general characteristics, except that it has a tap hole at the lowest point of the hearth. The combustion takes place over grate bars; the hot gases passing over a bridge wall are reflected downward upon the metal and are thence drawn up a tall chimney. The iron, being thus separated from the fuel, is more uniform and homogeneous, giving more reliable results than could be obtained with the ordinary cupola. The charge is about 20 tons of mixed charcoal pig, Nos. 2, 3 and 4, of Lanesboro or Muirkirk iron. The metal being placed upon the hearth of the furnace, about 6 hours are required to completely fuse it, and from 2 to 3 hours longer to bring the metal to the proper state before pouring. After the metal is "down" it is stirred with a pole, the sap and water therein, being vaporized beneath the surface of the metal, aids in a thorough mixing. Small samples of the heat are taken from the furnace at short intervals and cast into square test specimens about 1 foot long and tapering from 2½ to ½ inch; these specimens are broken under the hammer, and the time for pouring is judged entirely by the nature of the fractures thus obtained. The amount of coal consumed is about 14,000 pounds, or 37 per cent. of the weight of metal, which is nearly four times the amount required by an ordinary cupola. In the case of the air furnace, however, a portion of the fuel is required to refine the metal, oxidizing a portion of the carbon and inducing a chemical union between that remaining and the iron, so that the fracture is whiter and shows less graphite than common cast iron. The metal being tapped off, flows through a long trough of fire clay into the mould; midway in this trough is placed a large circular swirl basin, where a portion of the metal is first allowed to accumulate; the velocity is also here reduced, and the skimming is easily accomplished. The runners of the mould have a tangential component in reference to the axis of the casting, which produces a rotation of the whole mass of metal around the core. Water is kept constantly circulating through the core, and the cooling at once commences. When the mould is full, the runners are stopped up and the surplus metal switched off by a branch trough into a ladle. A portion of this metal is afterward poured directly into the top of the mould to supply a reduction in length due to shrinkage. The top of the casting is covered with charcoal, and a charcoal fire is built in the pit around the outside of the iron flask to keep the exterior from cooling too rapidly. In about 24 hours the core is removed and the water turned directly into the bore of the casting for a day or two longer. Fig. 1 shows the complete casting.

The casting is next placed in a gun lathe, which is of heavy build, with a long boring bar attachment instead of a tail stock. The gun is held and driven by a large chuck on the face plate. The other end of the casting runs in a semicircular bearing or steady rest. The boring bar has no rotary movement, but is fed toward the face plate and carries a reamer-like cutter head which enlarges the hole by several cuts to 11·8 inches. Meanwhile, ordinary turning tools are reducing the outside diameter, turning down the chase or forward taper and parting off the test disks and shrink head. The parting tools are run in nearly to the bore, the gun body is removed from the lathe, and the disks broken from the casting by the wedge and sledge. The body is now completed in the rough, the test specimens are machined, and the work on the casting is completed for the first contract.

The hole is next enlarged to within 0·1 inch of the final diameter by a somewhat novel tool, the idea being to overcome the difficulty always encountered with cast iron chips, and also to bore straight and not be affected in the least by the existing hole. The head carries but one tool, and the chips are caught and retained by a sort of tray. The course of the hole is governed by a long, accurately made follower or collar, revolving with the gun. Preparatory to the shrinking on of the first row of steel hoops, they are faced at the ends and bored to 31·5 inches diameter, 0·003 of an inch being the allowed variation for the latter. The outside of the body is now accurately turned to a varying diameter slightly larger than the inside of the hoops shrunk thereon. This difference is called the "shrinkage," and its exact amount has been determined mathematically by Captain Birnie. It varies along the entire length to be hooped, the purpose being to place each hoop in both rows under nearly equal tension. The average amount for the A hoops, however, is about 0·45 inch, and for the B hoops it is about 0·040 inch. The total compression produced at the surface of the bore due both to the hooping and to the Rodman system of casting is shown graphically by the upper curve in Fig. 2,

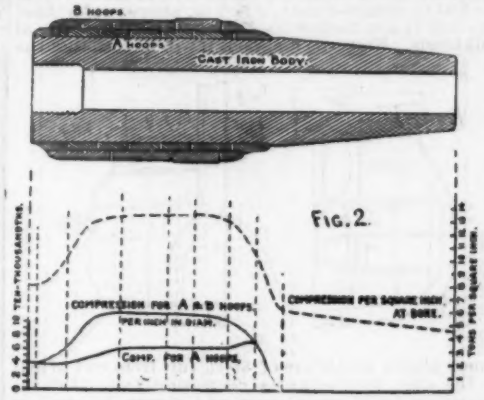

B HOOPS.
A HOOPS.
CAST IRON BODY.
COMPRESSION FOR A & B HOOPS, PER INCH IN DIAM.
COMP. FOR A HOOPS.
COMPRESSION PER SQUARE INCH AT BORE.
TONS PER SQUARE INCH.

FIG. 2.

where each tenth of an inch vertically represents a ton per square inch. As might be supposed, the diameter of the bore is slightly decreased by this treatment, the amount per inch being shown by the lower curve in same figure. It will be seen that the curves are very similar.

The mortar body is now placed on a special car, which holds it by the chase in a horizontal position, and is taken to the hooping department, wherein are the heating furnace, system of hoists and trolleys, sprinkling apparatus, and sewer connections.

The heating is done by city gas in a furnace sunk beneath the level of the floor. Air and gas are mixed in about the proportions of three to one by an injector, and forced into the furnace and pass into thirty-six vertical pipes, each containing four horizontal nozzles of a peculiar form arrived at by experiment. The liability of explosion has been done away with by an arrangement of sieves. The hoops to be heated are of various thicknesses, diameters, and lengths, and one carries the trunnions. Hence the burners have to admit of various easy and quick adjustments. The flames play directly against the hoop, both inside and out, and heat it to about 500° Fahr., or to a point where a certain minimum gauge will enter, but not far enough beyond to admit another 0·015 inch larger, the total expansion being about 0·09 inch. This type of furnace has proved capable of very close regulation and leaves little to be desired. During the heating the plane of hoop is horizontal, but it is changed to the vertical as it is hoisted out of the furnace. The hoop is now shoved

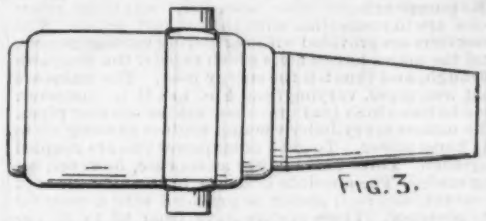


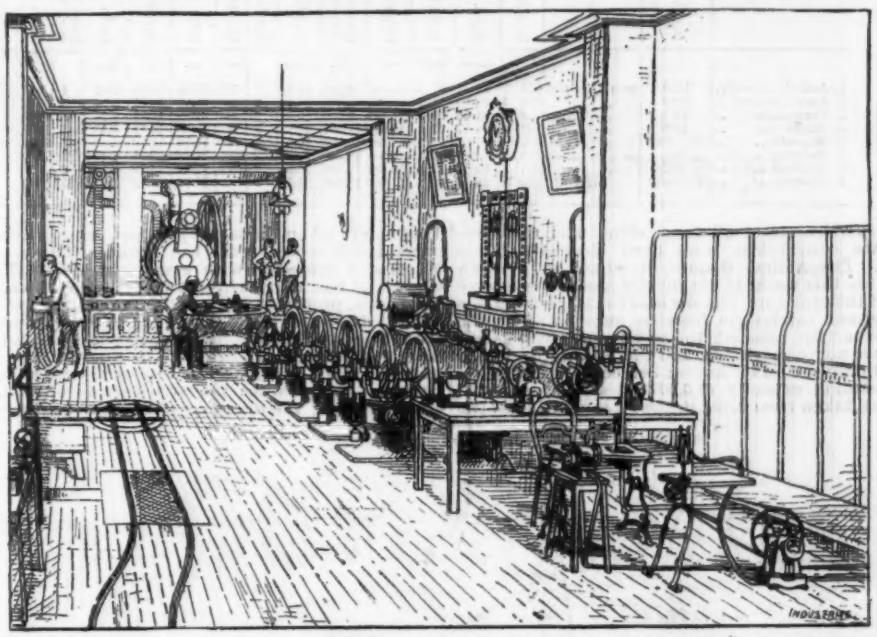
FIG. 3.

along by means of the trolley track till it slips over the gun and up to its proper place, when, by means of the hooping press, a force of 100 tons is exerted to make a tight joint between it and the one immediately in front. A plane of water from the sprinkling ring is then allowed to play on the forward portion, which soon contracts enough to grip the body, the plane of water is then moved slowly backward till the entire hoop is cold. The reader can see the necessity of cooling, and hence clamping, the forward portion before the rest, for otherwise the contraction ensuing would open up the joint, notwithstanding all the pressure that could be applied. The closeness of these joints may be inferred from the fact that after the exterior is turned they can seldom be detected.

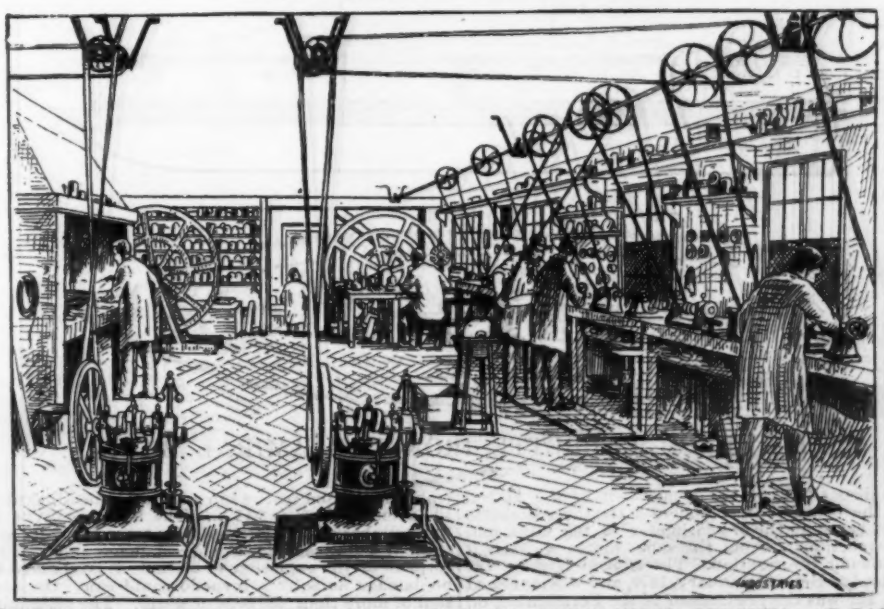
The hooping press used consists essentially of two screws, each of fifty tons capacity, pulling on a heavy cast iron collar directly behind the hoop. The forward ends of these screws pass through nuts on the ends of an equalizing beam, whose fulcrum bears against the stopper that closes the muzzle. This beam necessitates the operating of one nut only, and as they are furnished with ball bearings, the required pressure is easily obtained by two men pressing on a 6 foot lever. The exterior of the "A" hoops is now turned down as carefully as was the body, the "B" hoops shrunk on in a similar manner, and the entire exterior is turned to the finished diameters. The cut above represents the mortar as we now leave it.—*Stevens Indicator.*

PARIS CENTRAL PNEUMATIC POWER STATIONS.

IN Paris power is not only distributed by compressed air, but also by exhausting. This method of distribu-



THE INTERIOR OF CENTRAL STATION, PARIS, SHOWING PNEUMATIC EXHAUSTING ENGINE AND SET OF SMALL MOTORS.



APPLICATION OF SMALL PNEUMATIC MOTORS TO FANCY WOOD TURNING, AT PARIS.

tion is only used on a very small scale, but it is of sufficient interest to demand description and illustration. The central station is in Rue Beaubourg, and is for supplying small powers, varying from tiny motors up to two or three horse power, within half a mile or so of the generating plant. The central station contains three horizontal 100 horse power Corliss engines. The pumps exhaust from reservoirs, and these reservoirs are in connection with the exhaust mains. The reservoirs are provided with registering vacuum gauges, and the mains have meters which register the air drawn through, and thus tell the energy used. The mains are cast iron pipes, varying from 4 in. to 1 ft. in diameter. One to three inch lead branches act as service pipes. The motors are cylinder vacuum engines running up to 1¼ horse power. To get 3 horse power two are coupled together. Three horse power motors are, however, being made. The absolute pressure in the mains is kept constant, and each motor is provided with a centrifugal governor. These motors have from 68 to 80 per cent. efficiency. The charge is made by the number of turns of the motor; this is a little crude, as the speed is kept constant by the governor and the air used varies with the load; but, as an average, it is simple, and comes out, on the whole, fair. The scale of charges is somewhat complicated. The cost amounts roughly to about a shilling per horse power hour. This is very high, but many of the motors are very small, and are a great convenience where small powers are needed, as in watch and clock work, fine ornamental turning, etc. There are some hundred and fifty or two hundred customers. The station also has a 110 horse power engine, with two Gramme dynamos, for lighting.—*Industries.*

THE AMIRAL BAUDIN.

THE Amiral Baudin is one of the eight first-class ironclads (cuirasses d'escadre) which form so important a section of the French navy, and which constitute the most formidable means for attack or defense possessed by the country, as regards size, power, armament, and protection. In the *Aide Memoire de l'Officier de Marine* this squadron is divided into five types, to say nothing of three new ships which are designed but not yet commenced. The table given below shows the general particulars of all these ships, and their approximate cost, taken from Lord Brassey's Naval Annual. The Amiral Baudin, of which we give an illustration this week, is not by any means the newest vessel of the squadron, but she is of the largest tonnage but one, and carries the heaviest guns. Except the Brennus, not yet finished, the speeds these vessels can attain are not remarkable, and the Amiral Baudin is credited only with 15·2 knots; her coal supply gives her a steaming capacity of 3,000 miles. The annexed diagrams, taken from Lord Brassey's Annual, show the general disposition of the armor belt of the Amiral Baudin, the form and arrangement of the three barbette batteries carrying the 37 centimeter 53 ton guns, and two cross sections. From the same source we extract the following information. The Amiral Baudin was commenced at Brest in January, 1879, and was launched in 1883; she was the predecessor of the Formidable, on the same lines, and has no rigged masts, but two pole masts carrying the light turrets for the machine guns, look-out, search lights, etc. The twin screws are driven by three-cylinder compound engines, which indicate, with forced draught, 8,320 horse power; steam is supplied from twelve boilers with thirty-six furnaces. There are eleven transverse bulkheads, all carried up to the 3·94 in. armored deck, 3 ft. 7 in. above water line. The ship is also further divided by several longitudinal bulkheads. From the diagrams it will be seen that the

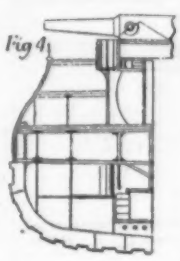


Fig 4.

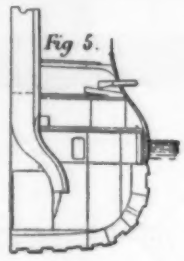


Fig 5.

armor plates, which are of steel, run from end to end of the ship, the thickness decreasing from 21·66 in. amidships to 14 in. at bow and stern; this belt is backed by teak from 12 in. to 14 in. thick. The plan shows that the barbette turrets are of a peculiar shape; they are protected with steel plates 10·5 in. in thickness. The armored deck is strengthened over the machinery and boilers, and the 7 ft. shafts for passing up ammunition to the turrets are also armored. As will be seen from the table, there are at present only six quick-firing guns on the Amiral Baudin, but it is likely this number will be increased and replace some of the numerous 5·51 in. guns now on board; the machine guns are, of course, made by Hotchkiss.

The Marceau, launched in January, 1884, from the yard of the Societe des Forges et Chantiers de la Mediterranee at La Seyne; the Hoche, built at L'Orient and launched in 1887; the Neptune, launched at Brest the same year; and Magenta, still unfinished at Toulon, are all on the same type, and present some important differences from the Amiral Baudin. The Marceau is protected with compound armor 17·72 in. thick, and has four turrets, two fore-and-aft and two amidships, protected with 13·78 in. armor; the fore-and-aft barbettes carry 50 ton guns, those amidships are 23 tons; all these ships are provided with torpedo discharge tubes, as shown by the above table. The hulls are built on the cellular system with a double bottom; below water the structure is of iron, and above of steel; the thickness of the armor is increased from the bottom to the top edge, and the thickness of the armored deck is 3·15 in. The hulls are divided into a number of compartments by transverse and longitudinal bulkheads to localize damage inflicted by a torpedo or the explosion of a shell; it is claimed that no damage done by a torpedo could cause the admission of more than 350 tons of water. The ammunition tubes, as well as the carriages for the heavy guns, are on the Canet system, and were made by the Forges et Chantiers de la Mediterranee; it will be noticed from the table that the armament comprises a large number of 14 centimeter and quick-firing and machine guns. These ships have three lower masts with light top masts, but they only carry fore-and-aft canvas.—*Engineering.*

TABLE GIVING PARTICULARS OF FRENCH FIRST-CLASS ARMOURED BARBETTE IRONCLADS.

NAME.	Date of Launching.	Material	Length.	Beam.	Draught.	Displacement.	Indicated Horse-Power.	Speed.	Number of Screws.	Coal Storage.	Armour. Belt.	Barbette Turret.	Deck.	Number of Torpedo Tubes.	Crew.	Approximate Cost.	Armament. Number and Nature of Guns. 37 cent. 14·57 in.	34 cent. 13·39 in.	27 cent. 10·63 in.	16 cent. 6·29 in.	14 cent. 5·51 in.	quick-firing	machine guns
			ft. in.	ft. in.	ft. in.	tons	H.P.	knots		tons	in.	in.	in.			£							
1. Amiral Duperré	1879	Iron and steel	312 3	65 7	27 8	10,487	8,120	14·3	2	700	21·66	11·81	2·56	4	664	570,000	..	4	..	1	14	2	12
2. Amiral Baudin	1883	" "	328 1	68 10	26 2	11,380	8,320	15·2	2	800	21·66	16·54	3·94	..	500	600,000	3	..	..	..	12	6	14
3. Formidable	1885	" "	328 1	68 10	26 2	11,441	9,700	16·2	2	800	21·66	17·72	3·94	..	500	555,320	3	..	..	..	12	13	5
4. Hoche	1886	" "	334 8	65 7	27 3	10,650	11,300	16·2	2	800	17·72	13·78	3·15	5	660	500,000	..	4	2	..	18	8	12
5. Magenta	Building	" "	331 4	65 7	27 3	10,581	12,000	16·5	2	800	17·72	13·78	3·15	4	660	500,000	..	4	..	..	17	12	8
6. Marceau	1887	" "	331 4	65 7	27 3	10,581	12,000	16·5	2	800	17·72	13·78	3·15	4	660	500,000	..	4	..	..	17	12	8
7. Neptune	1887	" "	331 4	65 7	27 3	10,581	12,000	16·5	2	800	17·72	13·78	3·15	4	660	..	..	4	..	..	17	12	8
8. Brennus	Building	Steel	360 10	65 7	26 3	11,000	13,000	17·5	2	..	17·72	17·72	3·94	5	660	..	..	3	..	10	..	12	8

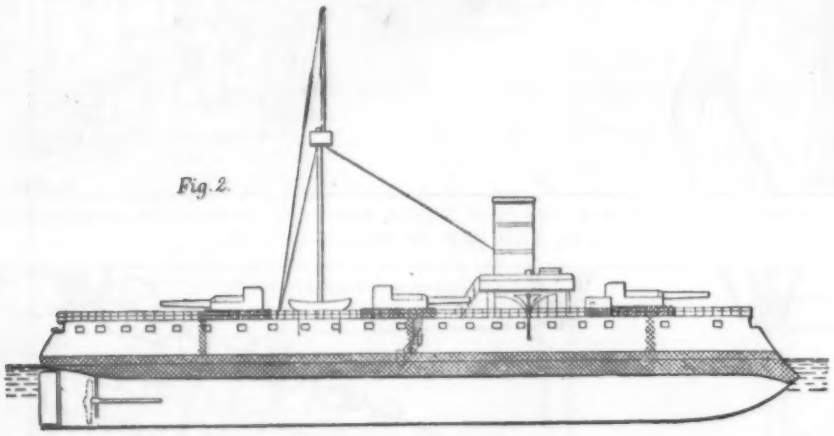


Fig. 2.

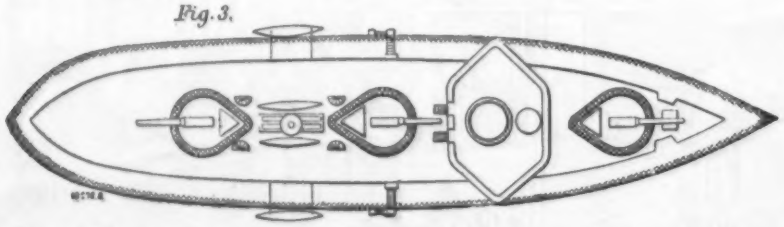


Fig. 3.

THE FRENCH BARBETTE IRONCLAD AMIRAL BAUDIN.

EVERY-DAY WORK IN THE RUBBER FACTORY.

By NICK R. AUGUR.

OF the many manufactories making rubber goods to-day, a large proportion do more or less white work, and for this purpose use oxide of zinc. Of course the companies that use this in the largest proportion are druggists' sundries men, whose goods are preferably white, and are supposed to be more pleasing to the eye and made with more regard to finish than many of the mechanical goods. The selection of the zinc used in work of this kind has a great deal to do in determining the fine finish that is secured. For example, a zinc that has a trace of lead in it, while it may look beautiful before it is vulcanized, is sure to give a mottled or cloudy appearance or a series of black streaks throughout the rubber compound. The only way to guard against this is to ship back a lot of zinc that contains this metal and buy a grade that is absolutely free from it. The manufacturers themselves, in many cases, claim not to have been able to discover the minute portion of lead that gave a bad result in rubber goods.

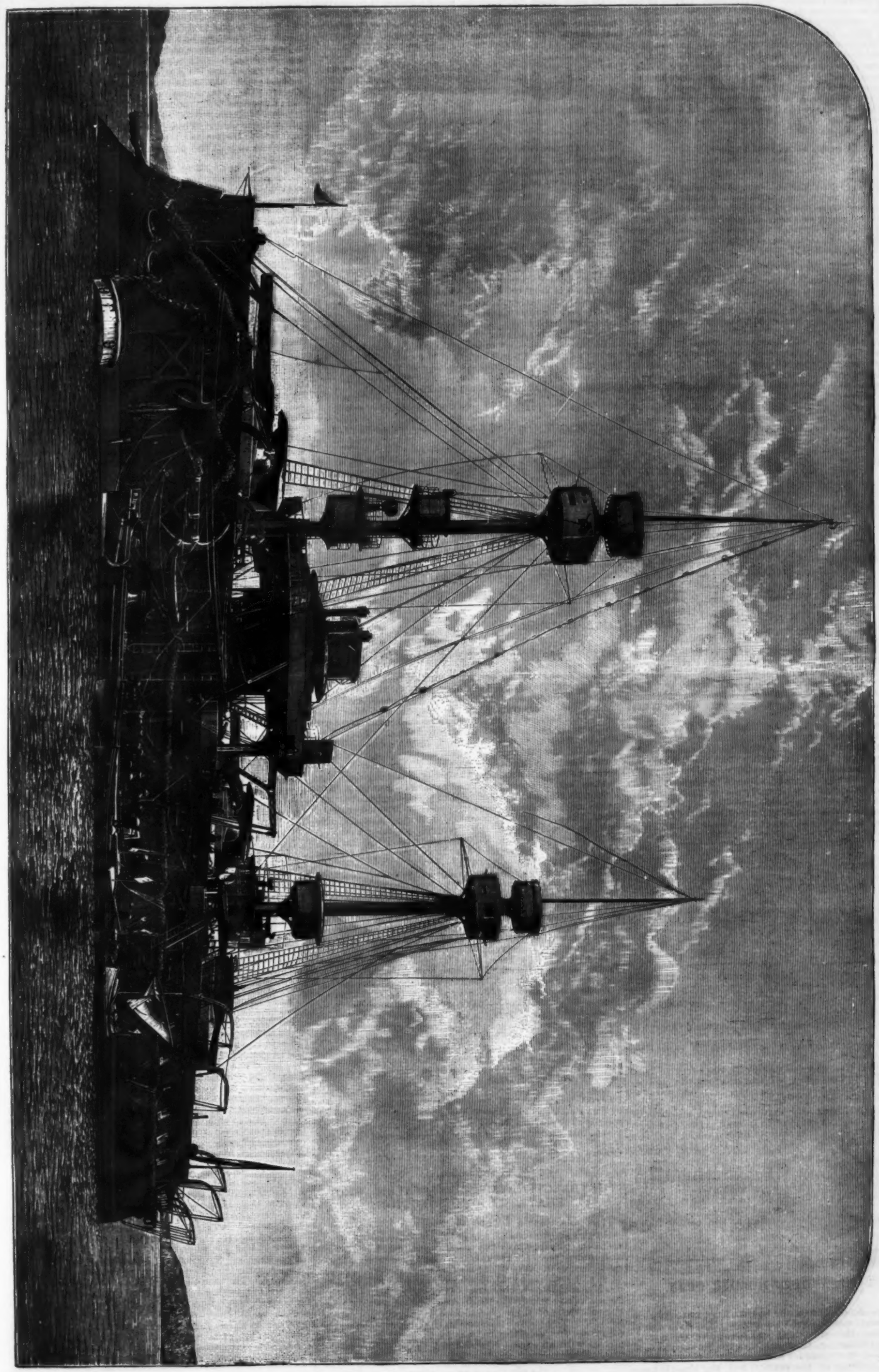
It has been asked why it is that certain brands of zinc will cake upon the rolls during mixing and cause a great deal of trouble, while others will become incorporated in the rubber and not trouble by clinging to the rolls. Our experience in this leads to the belief that it is due entirely to dampness in the zinc, and that it can be done away with by drying the oxide. Another reason why a damp lot of zinc should be dried out is because it is apt to be porous and full of blisters if used in work where blisters have the least chance to show themselves. In all cases where it is possible a separate mixing mill should be used for zinc work, as it is almost impossible to mix white stock on a mill that has had lead stock or lampblack stock run on it, as even a trace of the black will go far toward darkening a very considerable batch of the white. For white work that is moulded and cured in a steam heat, the moulds, as a rule, are dusted with French talc. The bulbs or hollow articles are themselves also very carefully dusted. This not only helps the whiteness of the goods, but prevents them from sticking to the mould. For white mould work that is cured in a press, a wash of rain water and either Castile or soda soap is used. This prevents the rubber from adhering to the metal, and does not in any way darken the white surface. This is used in almost any rubber mill where mould work is done, and will be spoken of to the uninitiated as a "secret preparation." The secret, however, has long since departed, and we are not telling anything that should not be given away in thus publishing it.

Speaking of moulds and mould work, for black work, very often the mould is dusted with plumbago, and it used to be the custom to dust a mould with golden sulphuret of antimony when red work was in progress. A better result is, however, obtained by using the soap preparation, and the moulds certainly remain in very much better condition. In spite of every precaution, moulds for bulbs and for other work will in time become caked by the preparation that is used to keep the rubber from adhering to the metal. When this caking gets so thick that it breaks off in portions, it is necessary to clean them. A bulb mould is cleaned by placing it, half at a time, in the chuck of a lathe, causing it to revolve evenly, and then cutting out the caking by running a sharp-pointed knife through it. It is afterward polished out with emery cloth and then wiped with a flannel rag. For various moulds different tools are in use for cleaning them, and every factory has its own.

Our London contemporary, the *India Rubber and Gutta Percha Trades Journal*, has something of a fling at the International Okonite Co., limited, and gives a formula which it says one of the expert chemists in London obtained from an analysis of the okonite compound. The compound reads:

Rubber	49·60
Sulphur	5·30
Lampblack	3·20
Oxide of zinc	15·50
Litharge	26·30
Silica	0·10

Now, we do not claim to know what the okonite compound is, but we would like to ask this expert if he thinks he has got the proportion of sulphur correct there, considering the fact that less sulphur is used in insulated wire than in almost any other compounds, unless it is dry heat compounds, and that the compounds are never vulcanized as hard as in ordinary soft rubber work. Is he sure that the 15·50 parts of oxide of zinc were not whiting? We would like to ask, also, if he did not find any trace of a peculiar gum that is used in toughening the okonite compound, and which in chemical analysis should make itself very evident.



THE FRENCH BARBETTE IRONCLAD "AMIRAL BAUDIN."

A line of rubber work that is overlooked when rubber factories are being catalogued is the manufacture of various kinds of porous plasters. It is perhaps not generally known that the gum that is at the base of these plasters is India rubber, and that it is mixed upon regular rubber mixing rolls much in the way that any compound is, except for this difference, that the compound is exceedingly sticky, so much so that a "doctor" is used on the back roll to get it off when thoroughly compounded. The process of calendering is also similar to that in vogue in any regular rubber mill, and everything, in fact, is done except the curing, which of course is omitted, as a sticky result is what is wanted rather than the reverse. An old fashioned formula for plasters, which is said to be used more or less, consists of

2 parts of massed rubber,
1 " Burgundy pitch,
1 " gum albanum.

This compound in various factories varies considerably, and, as is well known, different plasters have an active healing ingredient, and, aside from the regular compound, in many of them a peculiar sticky resin, known to the trade as friction resin, is added, to give the adhesiveness that is necessary in making the best of goods.—*Rubber World.*

MAGIC PHOTOGRAPHS—THE MYSTERIOUS PHOTOGRAPH.

DURING the last holiday season, we found in one of the bazars some small boxes containing a nice assortment of those invisible photographs whose easy development affords a harmless and agreeable pastime for children. . . . The process of manufacturing these magic photographs is as follows:

By means of any negatives whatever, positives are printed upon paper sensitized with chloride of silver,

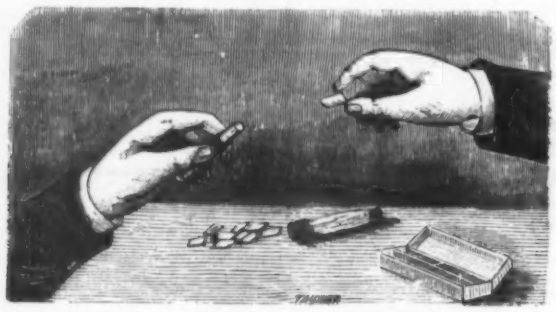


FIG. 1.—MAGIC CIGAR HOLDER.

and which may be found ready prepared in commerce. These prints are fixed in a bath of hyposulphite of soda (8 to 10 per cent.), without having been toned with gold, and are then washed with great care in order to free the fibers of the paper from every trace of the salt, which would cause the paper to turn yellow after it had been treated with mercury.

Having prepared a 5 per cent. bath of bichloride of mercury, we place our prints in it. Therein, the images will first gradually fade, and then disappear entirely. After the prints are thoroughly bleached, they are thoroughly washed with water and allowed to dry.

In order to make the latent image reappear, it suffices to immerse the white paper in a weak 5 per cent. solution of sulphite or hyposulphite of soda. This substance has the property of turning chloride of mercury black, forming sulphide of mercury therewith, and also

FIG. 2.

dissolving the chloride of silver which has formed in the bichloride of mercury.

In this double reaction, we find the whole secret of the magic photograph.

Amateurs might interest themselves in repeating these experiments.

A variant giving more piquancy to the surprise is to apparently suppress the revealing product that makes the latent image appear. This consists in fastening to the edges of and behind the print a piece of white blotting paper previously saturated with sulphite of soda. This done, it suffices to immerse the paper in water, when the sulphite will at once dissolve and the image will quickly reappear. The illusion is thus more complete. . . .

Magic Cigar Holders.—Some years ago, dealers in tobacco sold cigar or cigarette holders inclosed in cardboard cases in which they were accompanied with a small package of photographic paper, entirely white and about the size of a postage stamp.

These cigarette holders opened at the center like a

FIG. 3.—CIGARETTE HOLDER OPEN.

needle case. Some were so made that the photographic postage stamp was placed externally to the cylindrical part forming the sheath ($b\,b'$); in this case, b contained an aperture, a, that allowed the smoke to pass. Others, which were simpler and more diverting, opened like the preceding, at the center, but the sheath consisted of a small white glass tube, in the interior of which was placed the loosely rolled little sheet of magic paper.

In both cases, the tobacco smoke comes into contact with the photographic paper. After the smoking was finished, the magic paper showed a portrait or some other image that had developed upon it.

FIG. 4.

The ammoniacal vapors contained in tobacco smoke possess, like the hyposulphite of soda, the property of coloring black the chloride of mercury contained in the prepared paper.—*La Science en Famille.*

CONNECTING LIGHTNING CONDUCTORS TO GAS AND WATER PIPES.

PROF. L. WEBER has an article in the *Elektrotechnische Zeitschrift*, of July 4, in relation to this subject. He says Prof. Lodge's investigations were restricted by two presuppositions, viz., that the duration of a flash is very brief and something like a millionth part of a second, ordinarily, and that the discharge is oscillatory; consequently the only inference that could be drawn from them is that self-induction may be best avoided by exchanging the solid conductor for a flat or a hollow one, and by making the conductors branch as much as possible; further, that the best means of diminishing the dangerous spreading of the fluid, which is due to self-induction, is to augment the conductor's capacity, and that the most practicable method of doing this is to connect the conductors to the gas and water systems.

Now, says Prof. Weber, there is indubitable evidence that the duration of a flash may vary within very wide limits. There are flashes which do indeed last only for the millionth part of a second, such as those observed by Dove with his revolving disk, and these are badly described as brief duration flashes. There are, besides, flashes whose duration is half a second. These are called long duration flashes, and are further distinguishable from the others by their ruddy tint.

It is extremely probable that it is only long duration flashes which have the power to communicate fire, although violent mechanical and physiological disturbances may be occasioned by those of brief duration. That the latter may possess oscillatory characteristics can, by analogy with the artificial sparks produced with a battery, and on the authority of Prof. Lodge's observations, be accepted, but that they possess them normally has yet to be proved.

That there may be long duration flashes without these characteristics has been proved by photographs taken by the writer last summer and described in the reports of the Berlin Academy. That long duration flashes can also be oscillatory, he is not as yet in a position to deny, but the probability is against it. Naturally a multitude of variations on these two extreme types may be conceived.

It will now be seen, says Prof. Weber, that Prof. Lodge leaves untouched a class of flashes which is of long duration and not oscillatory, as well as another class whose characteristics are perfectly established. His investigations only take account of flashes whose characteristics are hypothetical, and their only practical value, therefore, is to confer fresh importance upon one of the oldest established types of conductor construction, that, viz., in which the conductors are attached to the gas and water systems, and possibly, to throw into relief the superiority of Melssen's system over that of Gay-Lussac.

The plan of construction for lightning conductors, the sufficiency of which has been made manifest by a century of use, will, Prof. Weber thinks, undergo no sensible alteration through Prof. Lodge's investigations, but rather will its usage be confirmed in every essential particular, and the difficulties which stand in the way of its wider adoption removed.—*Elec. Review.*

THE ELECTROLYSIS OF METALLIC PHOSPHATES IN ACID SOLUTION.

By EDGAR F. SMITH.

SOME experiments on the action of the current upon metallic phosphates have been published by Moore,* and more recently Brandt† has communicated his experience with the pyrophosphates dissolved in an excess of sodium pyrophosphate and also in ammonium hydroxide or carbonate. The experiments in this paper relate wholly to the deposition of metals from the solutions of their phosphates in normal phosphoric acid. The course pursued in the preparation of the solutions for electrolysis was to first precipitate the metals with an excess of disodium phosphate, dissolving the compound obtained in a measured volume of free phosphoric acid (sp. gr. 1·347), and then exposing this liquid to the action of currents of known strength. When operating upon mercuric solutions, prepared in the manner indicated, the deposition of the metal in the early part of the experiment was perfectly satisfactory, but as the decomposition advanced, a heavy white precipitate appeared in the solution, and, although it gradually suffered reduction, the metal that separated was so fluid-like that it mechanically carried down impurities; hence was unfit for electrolytic determinations, and the experiments in this direction were consequently suspended. Mercurous phosphate proved to be insoluble, or nearly so, in phosphoric acid. This is also the case with bismuth and lead phosphates. Therefore neither of these metals was available in the proposed experiments.

COPPER.

To a solution containing 0·0996 gramme metallic copper, as sulphate, 10 c. c. Na_2HPO_4 (sp. gr. 1·0358) and 3½ c. c. H_3PO_4 (sp. gr. 1·347) were added. The precipitated copper phosphate dissolved in ½ c. c. of acid, so that the deposition of metal occurred in the presence of 3 c. c. of free phosphoric acid. The total dilution with water amounted to 125 c. c. The current employed gave 0·15 c. c. oxyhydrogen gas per minute. The copper deposit weighed 0·1997 gramme. The metal precipitation was allowed to continue through the night. Later, two additional experiments were arranged in every respect similar to the one just described, increasing the current, however, to 0·5 c. c. oxyhydrogen gas per minute. The copper found was in (*a*) 0·0990 gramme, and in (*b*) 0·0994 gramme. The addition of an excess of ammonium hydroxide to the filtrates did not produce the slightest blue coloration. The metallic copper from the above experiments showed a rich red color. The metallic luster observed upon the metal deposited from solutions containing other free acids, *e. g.* HNO_3, was not noticed here. That the conditions of the preceding depositions will answer for the separation of copper from other metals is evident from the results recorded below. Strong currents deposit metallic iron and other metals from their phosphates in phosphoric acid solution, while they are unaffected by the feebler currents.

COPPER FROM IRON.

A solution containing 0·0996 gramme metallic copper, 0·1700 gramme metallic iron, 30 c. c. Na_2HPO_4 (sp. gr. 1·0358), and 4½ c. c. H_3PO_4 (sp. gr. 1·347), were diluted to 125 c. c. with water and exposed to the action of a current generating 0·6 c. c. oxyhydrogen gas per minute. The deposited copper weighed 0·0996 gramme. Additional experiments verified this result. The filtrates contained no copper.

COPPER FROM ALUMINUM.

Here the quantity of copper was the same as before, while the aluminum metal was 0·1000 gramme, 20 c. c. Na_2HPO_4 (sp. gr. 1·0358) with 3 c. c. H_3PO_4 (sp. gr. 1·347). The total dilution was 100 c. c. The current gave 0·3 c. c. oxyhydrogen gas per minute. The copper deposited weighed 0·0995 gramme.

COPPER FROM CHROMIUM.

Both metals were added as sulphates, the quantity of metallic chromium being in excess of that of copper. The volume of alkaline phosphate was 20 c. c., and that of the phosphoric acid 3 c. c. The final dilution and current strength were the same as in the separation of copper from aluminum. The deposition was made during the night. The metal obtained equaled 0·0994 gramme. It was brilliant red in color, similar to that noticed frequently by chemists in the separation of these two metals from each other. The chromium was oxidized to chromic acid. The filtrate gave no indication of unprecipitated copper. A duplicate experiment afforded a similar result.

COPPER FROM ZINC.

In this separation there were present 0·1500 gramme metallic zinc and alkaline phosphate and free phosphoric acid in the same quantities as with aluminum and chromium. The dilution was 100 c. c., while the current gave but 0·15 c. c. oxyhydrogen gas per minute. The deposited copper weighed 0·0993 gramme. The filtrate gave no coloration upon the addition of an excess of ammonium hydroxide.

COPPER FROM COBALT.

With 0·0968 gramme cobalt and conditions similar to those just given under copper and zinc, except that the current had increased to 0·22 c. c. oxyhydrogen gas per minute, the deposited metal was found to be 0·0995 gramme.

COPPER FROM NICKEL.

The nickel (0·1105 gramme) was present as chloride, while the conditions of experiment were similar to those in the preceding example. The deposit of copper weighed 0·0996 gramme.

In all of the experiments given above the copper deposited rapidly from the cold solutions. Before interrupting the current the acid liquid was siphoned off and replaced by water. The deposits were washed with cold and hot water. Alcohol and ether were not used. The drying was done upon a warm iron plate. The current employed was obtained from ten ordinary "crowfoot" cells. In each experiment the poles of the battery were about ¾ inch apart.

CADMIUM.

As this metal deposits from solutions containing free sulphuric acid,* it was expected that the same would occur in the presence of free phosphoric acid. This is proved by the following experiments: 10 c. c. cadmium sulphate (=0·1827 gramme Cd) were precipitated by an excess of Na_2HPO_4 (sp. gr. 1·0358) and the phosphate dissolved in 1½ c. c. H_3PO_4 (sp. gr. = 1·347). Total dilution 100 c. c. The current gave 0·6 c. c. oxyhydrogen gas per minute. Two determinations were made in this way. The found metal was in (*a*) 0·1839 gramme, and in (*b*) 0·1820 gramme. The (*a*) deposit showed a little sponginess, and this doubtless caused it to give a higher result than required by the theory. The filtrates from these deposits gave no cadmium reactions upon applying the usual tests for that metal. In two other determinations where the only change made in the conditions of experiment was the reduction of the

* Chem. News, 58, 209.
† Zeit. fur anal. Chem., 28, 581.

* This *Journal*, 2, 41.

current to 0·40 c. c. gas per minute, the deposited cadmium weighed in (*a*) 0·828 gramme, and in (*b*) 0·1833 gramme. These figures indicate complete deposition and that the method is reliable. Cadmium does not, however, deposit as rapidly as copper under like circumstances. It was also found advisable toward the close of the experiment to increase the current strength. The acid liquid should always be removed from the dish in which the deposition occurs before the current is finally interrupted. The deposits were washed and dried as described with copper.

CADMIUM FROM ZINC.

0·1827 gramme cadmium and 0·1500 gramme zinc (both as sulphates) were precipitated by 40 c. c. disodium phosphate, dissolved in 3 c. c. H_3PO_4 (sp. gr. 1·347), and acted upon in the cold for twelve hours with a current giving 0·35 c. c. oxyhydrogen gas per minute. The cadmium deposit weighed 0·1820 gramme. The entire dilution was 125 c. c. With a second cadmium solution (= 0·1057 gramme Cd), together with the same quantity of zinc as before, 20 c. c. Na_2HPO_4 (sp. gr. 1·0358), 3 c. c. H_3PO_4 (sp. gr. = 1·347), and 100 c. c. water, 0·1060 gramme cadmium was obtained. This deposit was crystalline, but in spots slightly spongy, which may account for its being somewhat higher than the theoretical. Two more separations of these metals were made, with a reduction of the phosphoric acid from 3 c. c. to 2 c. c., otherwise the conditions remained as before, and the cadmium obtained was in (*a*) 0·1057 gramme and in (*b*) 0·1051 gramme. The current strength in these depositions was 0·37 c. c. oxhydrogen gas per minute in each dish. *b* is low; its nitrate gave trace of cadmium sulphide upon testing with hydrogen sulphide. My experience has been that in experiments such as these it should never be omitted to increase the current for about one hour previous to the final disconnection.

CADMIUM FROM NICKEL.

Only two experiments were made with these metals. They were conducted in the same manner as those with zinc and cadmium. The cadmium found was in (*a*) 0·1059 gramme, and in (*b*) 0·1051.

CADMIUM FROM IRON.

The quantities of the metals were 0·1700 gramme iron and 0·1057 gramme cadmium. The alkaline phosphate and phosphoric acid were the same as with cadmium and zinc. Total dilution 100 c. c. Current 0·37 c. c. oxyhydrogen gas per minute. The deposited cadmium weighed in (*a*) 0·1058 gramme, and in (*b*) 0·1062 gramme.

CADMIUM FROM CHROMIUM.

In this separation the conditions were the same as with the preceding metals. Found cadmium was 0·1055 gramme. The deposit was spongy, and the reduction of the strength of the current seemed not to remove this undesirable feature.

CADMIUM FROM ALUMINUM.

The quantity of cadmium present was 0·2120 gramme, while the aluminum was in equal amount. The alkaline phosphate, free phosphoric acid, total dilution, and current strength were the same as with zinc and iron. The results obtained were in (*a*) 0·2122 gramme Cd and in (*b*) 0·2120 gramme Cd.

The separation of copper from the metals mentioned in connection with it was not attended by any difficulty whatever, but with cadmium compliance with the conditions mentioned was absolutely required, otherwise the results varied. In solutions containing free phosphoric acid, cadmium is unusually inclined to sponginess, so that concentration of liquid should be avoided, and the poles of the acting battery should not approach too closely to each other. The most favorable separation was found to be 1¼ inches and the proper dilution of the liquid 100-150 c. c. Such, at least, was the case in the separations just described.

COPPER FROM CADMIUM.

These metals have been separated from each other in the presence of free nitric acid,* and also in the presence of free sulphuric acid.† From the results about to be given, their separation in the presence of free phosphoric acid is also possible. Two experiments were conducted under the following conditions: 0·2452 gramme copper as sulphate, 0·1827 gramme cadmium as sulphate, 20 c. c. Na_2HPO_4 (sp. gr. 1·0358), and 10 c. c. H_3PO_4 (sp. gr. = 1·347), with a total dilution of 125 c. c., were exposed to the action of a current generating 0·10 c. c. oxyhydrogen gas per minute for a period of twelve hours, when the following amounts of metallic copper were obtained: in (*a*) 0·2451 gramme, and in (*b*) 0·2452 gramme. In a third experiment, with double the amount of copper present, the current was allowed to act through the night, and the deposited metal weighed 0·4904 gramme. Again, with a current liberating 0·2 c. c. oxyhydrogen gas per minute, conditions in all other respects similar to those previously mentioned, the found copper was 0·2451 gramme. Cadmium was not detected in these deposits. The filtrates showed no trace of copper.

Silver phosphate is readily dissolved by phosphoric acid, but from such solutions even the feeblest currents deposit the metal in a spongy condition, so that it was useless in the quantitative work. But from an ammoniacal solution of the phosphate the deposition of silver metal is quite rapid and satisfactory. Two experiments gave, with a current liberating 0·20 c. c. oxyhydrogen gas per minute, in (*a*) 0·1065 gramme and in (*b*) 0·1061 gramme Ag, the required being 0·1062 gramme. Ammonia just sufficient to dissolve the phosphate is all that should be used. As I have not observed this mode of depositing silver described in the literature of electrolysis, I include it here, although it is only to the department of acid phosphate solutions that I wish to direct attention.

The behavior of lead phosphate in alkaline solution has been recorded by me.‡ The results given are quite satisfactory. As already remarked, its phosphate being insoluble in phosphoric acid excludes experimentation in that direction.

One of the most interesting observations made in this study of acid phosphates and the electric current is that with manganese.

It is well known that from nitric or sulphuric acid solution this metal is deposited as dioxide by the current. In the presence of phosphoric acid, where there is a decided excess of the latter, the deposition of dioxide upon the positive pole does not take place. This behavior has enabled me to present the following separations of copper from manganese:

1. 0·1770 gramme copper as sulphate, 0·1500 gramme manganese as sulphate, 30 c. c. Na_2HPO_4 (sp. gr. 1·0358), 10 c. c. H_3PO_4 (sp. gr. 1·347), with a total dilution of 120 c. c., of were exposed to the action of a current giving 1 c. c. oxyhydrogen gas per minute. Copper found equaled 0·1765 gramme.

2. The conditions the same as in (1), except that the current gave 1·4 c. c. oxyhydrogen gas per minute. Found copper weighed 0·1770 gramme. The positive pole showed no dioxide deposition. When the current exceeded that given in (1) and (2), a pink coloration was observed about the anode. This non-precipitation of the manganese is very likely due to the formation of the phosphate of the sesquioxide, which is only decomposed, and then but partially, by much more powerful currents than were used in this separation.

The behavior of other metallic phosphates in acid solution is receiving attention in this laboratory.—*Amer. Chemical Journal.*

ELECTROLYSIS OF DIFFERENT SUBSTANCES.

By P. L. ASLANOGLOU.

1. *Water.*—On passing a current of electricity from six Fuller's mercury bichromate elements through ordinary London tap water for about twelve hours, the hydrogen pole (platinum) became coated with a white residue, which from time to time fell to the bottom of the electrolysis tube. This white residue having been analyzed, it was found to be calcium carbonate, which is contained in small quantities in ordinary drinking water.

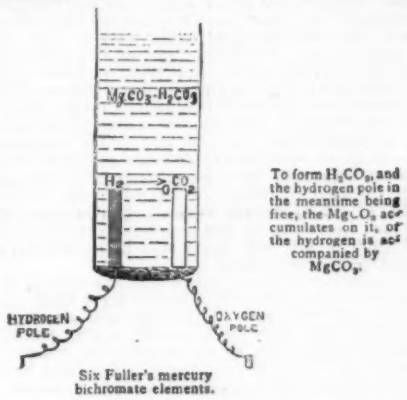
The oxygen pole (platinum) was free from any residue whatever.

During electrolysis hydrogen and oxygen were given off as usual.

2. *Magnesium Carbonate* was suspended in distilled water and CO_2 was passed through the solution, and, after filtering, the clear solution was tested for magnesium, which it contained in considerable amount. The results obtained were the following:

Hydrogen and oxygen given off as usual.

The hydrogen pole became coated with white residue, which fell to the bottom of the tube as in the previous experiment.

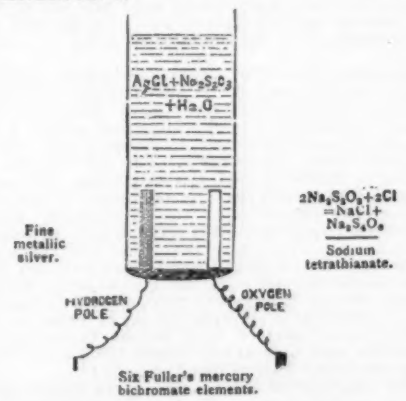

$MgCO_3 \cdot H_2CO_3$
H_2
O_2
To form H_2CO_3, and the hydrogen pole in the meantime being free, the $MgCO_3$ accumulates on it, or the hydrogen is accompanied by $MgCO_3$.
HYDROGEN POLE
OXYGEN POLE
Six Fuller's mercury bichromate elements.

The oxygen pole was free from any solid matter.

$$Mg(HCO_3)_2 = Mg + H_2 + 2CO_3 + O_2.$$
$$Mg + 2H_2O = Mg(OH)_2 + H_2, \text{ which escapes.}$$
$$Mg(OH)_2 + CO_2 = MgCO_3 + H_2O.$$

3. *Silver Chloride* dissolved in sodium thiosulphate ($Na_2S_2O_3$), filtered, and electrolyzed. The following results obtained:

Only hydrogen given off, and a thick gray precipitate, turning at once to black, deposits on the hydrogen pole, which shakes off to the bottom of the tube. The smell given off was that of sulphureted hydrogen. The black precipitate was tested and found to be very fine metallic silver.



4. *Lead Sulphate* dissolved in a solution of tartaric acid, neutralized by ammonia (ammonia tartrate), and filtered.

Hydrogen and oxygen were given off.

The hydrogen pole was coated with black residue, which smelled of ammonia, while the oxygen pole was colored a golden yellow, and in the course of a few hours the solution was of the same color, but gradually became darker.

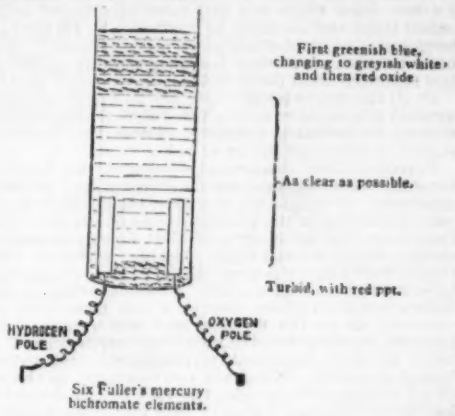
5. *Barium Carbonate* and *Strontium Carbonate* were suspended in distilled water, and CO_2 was passed through the solution and filtered.

Hydrogen and oxygen were given off, while a fine white precipitate coated the hydrogen pole and fell off to the bottom of the tube.

6. *Zinc Carbonate* was suspended in distilled water, and after passing CO_2 through it, was filtered.

Hydrogen and oxygen were given off with effervescence and bubbles of the two gases collected on the surface of the liquid.

The hydrogen pole was coated with a grayish black residue of zinc carbonate. The liquid became turbid, and a gelatinous precipitate floated on the surface, and by shaking the tube the precipitate fell to the bottom.


First greenish blue, changing to greyish white and then red oxide
As clear as possible.
Turbid, with red ppt.
HYDROGEN POLE
OXYGEN POLE
Six Fuller's mercury bichromate elements.

7. A mixture of *Ferrous Sulphate* and *Carbonate of Soda* was placed in a flask, which was then filled with distilled warm water and CO_2 was passed through for half an hour. It was left to settle and the liquid was poured, leaving the precipitate at the bottom of the flask, and fresh hot distilled water was poured over it, and CO_2 was then passed for half an hour; this process was repeated six times, during which time CO_2 was passing through the flask so as to prevent the iron from oxidizing. The last time it was left to settle for a few hours, and was then poured as quickly as possible through a filter, the clear liquid running into the electrolysis tube. The ferrous sulphate was thus converted into ferrous carbonate by carbonate of soda, and part of it was dissolved by passing CO_2 through. The liquid in the electrolysis tube was quite clear, free from signs of oxidation, etc. When it was subjected to a continuous current, hydrogen and oxygen were given off. Both platinum poles were free from any residue from the beginning to the end of the experiment. The result is shown by the above diagram.—*Chemical News.*

COLOR AND COLORING.*

By Prof. A. H. CHURCH, M.A., F.R.S.

LECTURE I.

IT was after considerable hesitation that I accepted the honor of addressing the Society of Arts on the subject which is to engage our attention to-night, and on the two remaining Monday evenings of the present month. I was doubtful as to the freshness of my material and as to my ability in presenting my opinions to your notice. Then, too, I remembered that Captain Abney had handled some parts of this subject so ably and so recently, in the course of lectures which he delivered in this room in 1888. I felt, however, that if I could but succeed in developing your interest in the connection between the science of color and the art of coloring, I might perhaps be justified in acceding to the request of your council.

The syllabus of the course indicates the limited range of these lectures, and shows that they make no pretension to an exhaustive treatment of the subject of color. To my "Manual of Color," published in 1887 by Messrs. Cassell & Co., I must refer my auditors for a systematic exposition; in this place I purpose developing some only of the topics discussed in my book, especially in relation to our everyday surroundings. But I cannot refrain from expressing the great debt I owe to the "Modern Chromatics" of Professor Ogden Rood, published just eleven years ago. You will notice how often I have to cite his authority and to quote his results.

Definition of Terms.—The sense given to certain terms, which will be freely used in these lectures, ought to be explained at the outset.

The essential difference between tones lies in their brightness or luminosity, that is the amount of optical sensation caused by a given area. Tints contain differing amounts of white, shades contain differing amounts of black, broken tints contain differing amounts of gray—all these are tones; the particular descriptions I have given being so framed as to apply to colored and uncolored substances rather than to lights. When a series of tones is said to constitute a scale, it is formed by the addition of equal increments of the modifying element. Each hue admits of three scales—the reduced scale, made up of tints; the darkened scale, made up of shades; the dulled scale, made up of broken tints. Theoretically, each possible scale starts from the pure normal color; practically, when we deal with pigments and other colored bodies and not with lights, such a perfect starting point is unattainable. It should be added that the tints of black and the shades of white are the grays, and that passage tones are distinguished from the tones which constitute the above named scales in one respect only; they pass by imperceptible gradations from the beginning to the end, and not by definite steps of ascertainable value.

Constants of Color.—Of these there are three, namely, hue, purity, brightness. The hue of a color appeals at once to the eye; we endeavor to identify it, perhaps to name it, calling it red, orange, yellow, green, etc., and so on. The purity of a color refers, in the accepted language of chromatics, to its freedom from white; in this sense no pigmentary color is pure. In the spectrum, under certain conditions, we have pure colors. The brightness or luminosity of a color is measured by the total amount of light sent to and perceived by the eye, and is independent of hue and of purity. Colors which do not sensibly differ from white are therefore far removed from purity, are bright because the white

* This *Journal*, 2, 42.
† Ibid., 12, 110.
‡ Proceedings Am. Phil. Soc., 1887.

* Recent lectures before the Society of Arts, London. From the *Journal* of the Society.

light freely reflected from them produces more optical sensation than any positive color. On the other hand, a pure color is not necessarily a bright color, for not only is the absence of white light the exclusion of the cause of the highest luminosity, but a pure color may be so low in tone as to be barely recognizable. When a color is at once as bright and as pure as possible, it is called saturated; such a color may be called "full" in speaking of pigments and other colored materials. Its less pure tones are, as I have mentioned before, called tints, and are more or less "pale." Its less luminous tones or shades are more or less "dark." Such of its tones as are at once less pure than its shades and less luminous than its tints are more or less "dull."

Of all the above terms there are two only which are applied in a manner somewhat different from that belonging to ordinary parlance. These two terms are shades of color and purity of color.

Primary Color Sensations.—Color is, we know, an internal sensation, and has no external and objective existence. It originates, in all the cases which we purpose discussing in the present course of lectures, in the impact on the optic nerve of that energy or mode of motion which we call light. Certain waves or vibrations which affect the nerve fibrils of the eye are translated by the brain into color. I do not intend to place before you the various theories which have been propounded as to the method and mechanism of this translation; they involve numerous intricate and obscure physical, chemical, physiological, and psychological problems. But I ask you to accept, as the best of all working hypotheses, the view of the subject taken by Dr. Thomas Young in 1802, and since developed by Helmholtz, Maxwell and Rood. The idea that there are three primary colors must be abandoned, but that of three primary color sensations may be very conveniently accepted, at least provisionally. What selection shall be made has been debated on various grounds. Several triads have been chosen, but a certain red, a certain green, and a certain blue have been accepted by some of the most distinguished investigators of the subject. I venture to add my own testimony as to the superiority of the triad of red, green, blue, over that of red, green, violet. With lights which provoke these three color sensations we can obtain all the colors of the spectrum as well as the purples which do not exist therein. Equivalents—I say equivalents, not equal quantities—of the standard or normal red and green produce the normal yellow; of the standard or normal green and blue produce the normal sea green; of the standard or normal blue and red, the normal purple. Intermediate colors are produced when the quantities of the two lights, which are together received by the eye, are not equivalent. Thus with red and green an excess of red produces orange; with green and blue, an excess of green produces a greenish sea green; with blue and red, an excess of blue produces a bluish purple or violet. No tertiary color is possible, the colors called tertiary by artists being broken tints of the three primaries and of the three normal secondaries. In fact, if you mix the three normal colored lights in their proper equivalents together, you get nothing but white or gray if the brightness of the lights be small; and if you mix these three normal lights together in any other than equivalent proportions, you get tints of the primary or secondary colors—that is, these colors mixed with white. By using the initial letters of the various normal colors to represent their equivalents, we may place the above results in the form of equations, which we will give after the manner adopted by chemists:

R + G = Y, or yellow.
2 R + G = O, or orange.
G + B = S, or sea green.
2 G + B = greenish sea green.
B + R = P, or purple,
2 B + R = V, or violet.
R + G + B = W, or white.
2 R + G + B = W + R, or pale red.
2 R + 2 G + B = W + Y, or pale yellow.
R + 2 G + 2 B = W + S, or pale sea green.
2 R + G + 2 B = W + P, or pale purple.

An essential difference between the colors produced by mixing lights and those produced by mixing pigments consists in this, that the addition or commixture of lights produces increase of brightness, while the commixture of pigments diminishes brightness. This difference of result is caused by the fact that the mixture of two lights possesses the added brightness of each of its elements, while the color resulting from the mixture of two pigments possesses merely the residual brightness left after a twofold or manifold absorption of light. For when blue and red lights are mingled on the retina, the eye receives the combined brightness of both, but when the blue and red pigments are mingled, the eye receives only that portion of the light which has escaped the absorptive action of both the blue and the red pigments. In this and similar cases the dullness arising from absorption is very marked, and an artist who wishes to secure the greatest possible brilliancy in his work avoids, wherever he can, the commixture of pigments, rather placing touches of color side by side, so that the colors they severally reflect shall mingle on the retina; the works of Samuel Palmer, William Hunt, and J. F. Lewis may be named as illustrating this method.

But there is a second difference between the colors produced by mingling lights and those produced by mingling pigments. This difference is not one of brightness or of purity; it is a difference of hue. You know the effect of mingling yellow and blue pigments together on the palette is the production of a green, more or less decided and bright, according to the chromatic constitution of the two pigments employed. But the commixture of yellow and blue lights in equivalent proportions results in the production of white more or less bright—that is, either white or a shade of gray—according to the brightness of its constituents.

If there be an excess of yellow light the color produced is pale yellow; if an excess of blue, pale blue. You may prove this point by the use of Maxwell's rotating sectors. Take the same two pigments, chrome yellow and ultramarine blue, which mingled on the palette produce green—rather a dull green—and mingle the lights they reflect, by the method of rotation on the retina, and you get a white of low luminosity, that is, a gray. But as in this case there is not the double absorption produced by the commixture of pigments, the gray is brighter than the green made by such commixture, and you will have to add much black to it (by means of a third sector of black) to obtain the same low degree of luminosity by rotation. I have purposely selected for citation this case of the mingling of blue and yellow, because it is the crucial instance by means of which is most strikingly shown the difference in hue above named, and it also serves to demonstrate the fallacy of the still prevalent notion that blue and yellow lights produce green. When green is formed by the mingling of two pigments, one yellow, the other blue, this result is attained by the suppression of the yellow and blue and the survival of the green which was present in both. So when white light, transmitted through a yellow and a blue glass, appears green, it is the residual green which has escaped absorption by both glasses which colors the emergent light. We know that the simple yellow of the spectrum, and the compound yellow produced by the mixture of red and green lights, affect the red and green nerve fibrils of the retina in exactly the same way, and it is for this reason that we affirm that yellow is a compound color sensation, and not one of the three primaries. I do not now dwell further on this point, as I have dealt with it at length in chapter vii. of my "Elementary Manual of Color," to which I beg to refer you for a fuller treatment of the differences between mixtures of lights and mixtures of pigments. I ought, perhaps, to mention here that the advocates of the red-green-blue theory of three primary color sensations, while denying the truth of the explanations afforded by the red-yellow-blue theory of Brewster, do not contest the occurrence of the chromatic phenomena presented by the admixture of pigments, or by the transmission of light through colored media, which Brewster's theory incorrectly interprets.

Classification and Nomenclature of Colors.—The simplest arrangement of colors must include white, a balanced or neutralized compound of two or more hues; black, the negative correlative of light and color; and the positive hues, with their tints, shades and broken tints. In bare outline it may be given thus:

DARKNESS		Black.
LIGHT	*Colorless*	White.
		Grays or shades of white.
	Colored	Hues.
		Tints, shades, and broken tints of hues.

But directly we endeavor to enter into further details, to give quantitative values and appropriate names to our many materials, we are confronted by serious difficulties. Whites and grays must have their brightness determined; all other tones require the determination of the three constants of color, namely, hue, purity and brightness. The fixed lines of the pure normal solar spectrum enable us, it is true, to locate all pure and saturated hues save the purples. Prismatic analysis reveals the chromatic elements of any color; the methods of shadow photometry enable us to ascertain relative luminosities, but the intelligible expression of our results in reference to definite standards has not yet been attained. The problem is, moreover, greatly complicated by reason of certain modifications of tone or of hue caused by contrast, dilution with white, etc., etc., as well as by the immense number of colors, with their shades and tints, which the human eye is competent to distinguish.

Of the modes of classifying colors, the cone of W. Von Bezold and the cube of W. Benson have many merits, but are not free from limitations and even defects. The color cube may be described in a couple of sentences, so far at least as its principle of construction is concerned. At one solid angle of the cube black, or the absence of light, is placed, at the opposite solid angle white. At the three solid angles nearest to black the full red, green, and blue are respectively placed, while at the three corresponding and opposite solid angles nearest to white the three complementary secondaries occur, namely, sea green, purple, and yellow. The beautiful diagrams in Mr. W. Benson's "Principles of the Science of Color" will fully explain the position of tints and shades in the cube.

The chromatic arrangement of Chevreul is vitiated by the adoption therein of the erroneous theory of the red-yellow triad, nor are the hues represented referred to a definite standard. Radde's color chart, though nominally based on certain spectrum colors, lacks precision in plan and execution. The scales of Lovibond's tintometer are represented by numbered and named glasses, to a certain arbitrarily fixed pale tint of which the value of one unit is given, and then the true chromatic elements of these glasses have not been determined.

The nomenclature of colors is intimately connected with their classification. It has difficulties all its own, owing to (1) the shifting meaning of well known color names; (2) the difficulty of coining new names. Purple sometimes means dark blue, sometimes a color half way between violet and crimson. The old German verb *bleuen*, to strike or beat, has originated the modern German *bläuen*, and there is no longer a distinction between the procedure of the schoolmaster and the laundress, though *blauen* is given in some dictionaries for to dye blue, *bläuen* to beat blue, but *bläue* is the color blue. The system, if such it can be called, of the mineralogist Werner (1774) included 92 terms arranged in nine groups. It lacks accuracy and orderly sequence, but is of interest in showing the use of terms for designating colors derived from certain typical animal, vegetable, and mineral substances, the hues of which vary but little. (See "Color," page 63.)

The long list of color names given to silks by the Lyons manufacturers will furnish some expressive terms, but many of the names are quite arbitrary and fanciful. R. Ridgway's "Nomenclature of Colors for Naturalists" (Boston, U. S. A., 1887) is useful in giving at once many color names, and actual water color washes of pigments representing them. Unfortunately, many of these names are very vague (dahlia, aster, phlox), and they are placed in an order based on no recognizable chromatic system. The 51 degrees of the *cyanometer*, for measuring the blue of the sky, serve to define its tone only, not its hue nor its purity.

We want an international color conference, in which artists, manufacturers, and scientists shall be represented. We want an agreement upon the names to be assigned to a number of different hues. We want representations of these standard hues reproduced in enamel, preserved like our standards of weight and measure, and distributed to every educational institution in the United Kingdom.

For my own part, I should be content to employ a combination of the systems of name and of number in the nomenclature and classifying of colors. The importance of having a definite nomenclature of quite intelligible character at our disposal when we are talking or writing about the decorative employment of color is so important that I venture to make a few suggestions which may tend toward the attainment of this object.

Let, then, the equivalents for the full red, the full green, and the full blue (as already described) be represented by the symbols R, G, B, the sea green, the purple, and the yellow, which are the several complementaries of the above hues, being similarly expressed by the symbols GB, RB, and RG. The capital letter represents the hue. Where no number is subscript, 1 equivalent is meant. For lower or higher luminosities decimals are used. If the sea green, to select one instance, inclines toward green, that is, has more than one equivalent of green in it, we may easily express this modification of blue by a fractional addition to the symbol for green and a simultaneous fractional subtraction from the symbol for blue. Such a series would result as this:

GB	= Sea green.
G_{11} B_9	
G_{12} B_8	
G_{13} B_7	
G_{14} B_6	
G_{15} B_5	= Greenish sea green.
G_{16} B_4	
G_{17} B_3	
G_{18} B_2	
G_{19} B_1	
G	= Green.

The corresponding modifications in the five other principal series of colors would be expressed in a similar manner, the symbols, etc., being used exactly in the same way as in chemical notation. In order to obtain a scale in a concrete form, I would recommend the use of Maxwell's rotation method, by which each step in the gradation could be matched. I would use for the series between sea green and green two disks painted with as near an approach as possible to the full normal green and the full normal blue, and the former should be increased and the latter diminished (in the form of sectors) in accordance with the system I have suggested. The rotation color produced at each step should be copied, or rather matched, and would then take its place in the series with a definite symbol attached to it. By the introduction of a white sector similarly treated, the tints of any color could be made to match; with a black sector the shades, with a black and white sector the broken tints. The symbol for black may be conveniently called Z, that for white should be R G B or W, as the case may require. But it is also possible to express the shades of a color by reducing its luminosity, and the broken tints by at once reducing its luminosity and adding white. Here are the symbolic expressions or formulæ for such changed hues:

S	= GB	= Sea green.
S_4	= G_4 B_4	= A shade of, or darkened, sea green.
SW_4	= GBW_4	= A tint of, or a pale, sea green.
S_4 W_3	= G_5 B_4 W_3	= A broken tint of, or a dull, sea green.

In the case of pigments or other colored materials the proposed symbols, though quite exact enough for any purpose for which they are employed, will not admit of accurate analysis. This is due to the fact that no pigment reflects a pure colored light, there is always some white mingled with it, rarely less than 20 per cent. of the whole. And even with colored lights there are also variable sources of error, for the addition of white light to colored light, and also the reduction of its luminosity, alters the original hue. To this change, which occurs also with pigments, and often in a very conspicuous manner, I shall invite your attention shortly.

Luminosity of Pigments.—One often hears the remark with reference to a work in black and white, an etching or line engraving, for example, representing a colored picture, that it has got good color in it. Such an expression may be interpreted to mean that the relative tones of the original are preserved in the copy, and suggest the force of the original colors. Now it requires much experience and singular skill thus to value and interpret the relative luminosity of differently colored portions of a painting. An aid in the work of translation is afforded by making determinations of luminosity or brightness by means of shadow photometry, or by comparing the brightness of various white and colored materials with the brightness of grays of known composition. The latter method, though not very easy or very exact, involving the use of black and white sectors in the rotation apparatus, gives results which are, at all events, approximately true. These results represent the comparative luminosities of the particular specimens of pigments, etc., employed, and vary somewhat with the method of applying the pigment, its thickness, and the medium (if any) used. The following figures were obtained in this way, some by Professor Rood and others by myself:

Chinese white, dry, in thick layer on pastel paper	100
Plain white paper	90·9
Whatman's paper (not hot pressed)	88·2
Chrome yellow, pale water color wash	73·0
Emerald green, pale, in thick paste	44·2
Cobalt blue, water color wash	32·2
Vermilion in thick paste	23·4
Natural ultramarine	8·3
Artificial ultramarine	6·9
Black paper	4·7
Lamp black, dry, in thick layer or pastel paper	0·8

I cannot help thinking that a more extended series of comparative luminosities would prove useful to the translators into black and white of works executed in color.

Effects of Varying Illumination.—The very considerable alteration of appearance experienced by colored materials when the hue of the light by which they

are rendered visible is changed is rendered familiar to us by the case of pictures and dresses, seen first by candlelight and then by ordinary daylight. We discover that what we thought was purple is really violet, crimson is purple, green is blue, and so forth. The deficiency of the more refrangible rays of the blue end of the spectrum, and the superabundance of the less refrangible rays of the red region in the light of burning oil and gas, and even in that emitted by incandescence electric lamps, furnish the explanation of these changes. It is of course more conspicuously evident when we view richly and variously colored objects in a light which is virtually monochromatic. The pure orange yellow of sodium cannot furnish the vibrations to which the majority of hues are alone capable of responding; only what is yellow can be seen, and even in this case not the yellow compounded of red and green vibrations. But I must not enlarge upon this point, as it has been often treated and at length elsewhere; and I want to direct your attention to those changes of hue in colored objects which are caused by alterations, not in the hue of the incident light, but in its brightness. The observant student of nature will have learned that the hues of many colored objects are most characteristically brought out by a comparatively moderate illumination. The chief cause of this phenomenon is often traceable to the large excess of unaltered white light, which such objects reflect or scatter when the illumination is intense, while when the illumination is moderate it just suffices to develop properly the particular hue of the material. I recollect a case in point. Wishing one day to show to a connoisseur in precious stones a fine aurora-colored zircon, which had lately been cut for me, I took the specimen into the sunshine. The color was so altered and so impoverished that my pride in the recent acquisition was humbled. The stone was distinctly inferior to a similar specimen in the British Museum. This pallor was not the result of the glittering reflections from the polished facets of the gem, but the colored light reflected to the eye from the lower facets was greatly reduced in purity by much admixture of white light.

Out of the strong light the specimen resumed its rich and beautiful appearance, and showed, moreover, not only a much deeper, but a much redder and less yellow, hue than when sunlight fell upon it. Painters have long been familiar with such changes of hue. If you examine the works of the great colorists of the Italian schools, you will see many striking examples of their appreciation of this natural phenomenon; indeed, I may say that these changes of hue with changes in the brightness of illumination have been not infrequently much accentuated, even greatly exaggerated. At all events, artists have long known that the high lights of a self-colored drapery cannot be properly represented by merely adding white—that is by forming tints of the same hue—although it does indeed sometimes happen that the addition of white paint to one having positive and strong color brings about changes of hue analogous to those we have been considering. Be it remembered that I am not now speaking of those purely accidental modifications of hue which are caused by reflections from colored objects, and which often cause a white drapery to assume the beautiful orient tints of the pearl.

If increase of light above what we may call a normal standard (one capable of showing in perfection a color) effects a change in hue, so also does decrease of light, although in an opposite direction. These changes of hue are well brought out in the following table:

Decreased Light.	Standard Light.	Increased Light.
Purplish	Red	Scarlet.
Red	Scarlet	Reddish orange.
Brown	Orange	Yellow.
Olive green	Yellow	Paler yellow.
Greener	Yellow green	Yellower.
Greener	Blue green	Bluer.
Violet blue	Blue	Turquoise.
Violet	Violet blue	Blue.
Violet purple	Violet	Bluer.
Purplish violet	Purple	Red purple.

Similar changes of hue occur when colored lights instead of colored objects are reduced or increased in brightness. Thus by lowering the luminosity of a pure solar spectrum, there will not only be a selective reduction or even extinction of some of the constituent hues, but also a shifting of the position of the hues. The red will invade the orange region, so that the line D, for example, will be bordered by a kind of red lead color. The green will extend toward the sea green, and even include the line F, and the pure blue will contract. We should then describe the darkened spectrum as practically consisting of red, green, and violet.

By a further reduction of brightness the red will become brownish, and the green and violet dull. In the next stage the violet disappears, the green is more dim, while the brownish red acquires a sort of chocolate hue. The last color to be recognized is a very faint green hue. I ought to mention in this place that when white light is added to colored light, the changes of hue which occur are generally to be explained by the statement that they are such as would be produced by a slight admixture of blue light with the white light.

The bearing of these observations upon pictorial and decorative work in color are obviously of considerable moment. If we want to be sure of the chromatic effect of a decorative scheme, we must arrange and modify its elements in such a way as to adapt it to the usual illumination of the apartments in which it is to be carried out: and here one curious result may be noted. In a very dimly lighted room, saturated and comparatively pure colors may yield delicate and refined harmonies, while the same colors in a blaze of strong daylight, or direct sunshine, may also lose their garishness because of the large amount of white light which then becomes mingled with the proper hues they reflect. But with a medium illumination these saturated colors, if freely used, become intolerable, just because they are perceived in their original strength. We thus learn how it is that a scheme of coloring which seems exquisitely choice when occurring in the dimly lighted apartments of a Cairo or Damascus house may become to the last degree crude when transferred to the full illumination of an English home, where the walls are pierced with large windows of plate glass admitting floods of light. The employment, under such altered conditions, of color saddened with black and dulled with gray has been long recognized and practiced as one of the easiest ways of modifying the crude effect of such chromatic arrangements. If saturated colors are still used we reduce their area, or employ them in such small and involved touches that the mingling of their hues produces what Owen Jones called a neutralized bloom.

Before I leave this important subject (of the effects of varying degrees of illumination upon the hues of objects), I wish to direct your attention to a very simple and decisive class of experiments, by means of which some of these changes of hue of which I have spoken may be recognized. You need only take some pieces of richly colored material, paper, cloth, or silk, of uniform hue, and partially crush and fold them, so as to get various portions illuminated in different degrees. An orange colored silk will look yellow in its high lights, and brown in its hollows. A blue paper will appear violet in its shaded parts, and of a purer blue, or perhaps of a somewhat greenish blue, in its projecting portions. A crimson cloth will seem scarlet where it catches most light, and crimson where it reflects the least. These changes of hue are in part due to errors of judgment, but they are none the less real.

Our next subject for study is intimately allied with that we have just been considering. I regret that the narrow limits of my available time will permit me to give little more than the barest reference to it. I refer to the alteration of hue caused by the addition of white, of gray, and of black to a pigment. White added to a red pigment does not usually produce just a paler tint of red, but the new tint varies in hue, tending in some cases toward crimson, in others toward scarlet. The dilution of a transparent red pigment with a colorless medium—that is attenuation of its thickness—produces analogous alterations of hue. Similar changes are caused in pigments of other colors by dilution and by commixture with white substances. Some of the changes produced by adding black are perhaps more striking.

Rood found that, on mixing carmine with lamp black, the mixture on the palette was more purplish in hue than the colors obtained by mingling the pigments optically by the method of rotation. This approach to purple was of course due to addition, with the black, of more blue to the carmine. An analogous observation, also due to Rood, relates to the admixture of black with white. Black pigments as free as possible from any tinge of positive color are generally observed to yield a bluish gray when mixed with white pigments. This result has usually been attributed to the fineness of the particles producing a blue by the same action on the light as an opalescent medium exerts. But Rood found that when white and black are mingled optically on a rotating disk, the gray they yield is matched in hue (not in brightness) by a white disk into which much blue (in one case 17 per cent.) has been introduced by means of a sector covered with a strong wash of indigo.

Dichroism is the next topic for our study. This term has been applied to similar phenomena produced in similar ways. A liquid or solid is said to be dichroic when the light which is transmitted through it differs in hue as well as in tone when the thickness traversed differs. Many liquids, such as solutions of double potassium and chromium oxalate, and potassium permanganate, well illustrate the phenomenon, so do many solids, such as copper sulphate, and several kinds of colored glass and gelatine films. But there is another kind of dichroism occurring in solids which are not optically homogeneous. Many crystals are dichroic, or even pleiochroic, for when white light is sent through them in different directions it suffers thereby different selective absorptions, and so the emergent beams are differently colored. The ruby, the emerald, and the tourmaline among precious stones are characteristic examples of this group of dichroic phenomena. Even a third class or group may be named, where the light transmitted differs in color from that reflected and scattered, solutions of chlorophyl and of uranin, and the solids uranium glass and fluorspar belonging here.

The first class of dichroic phenomena (depending upon the thickness of the colored medium) is largely concerned with the production of beautiful quality in color, as we shall see in the next lecture. It depends upon the increasing absorption of certain of the constituents of white light with increasing thickness of the medium. Thus, a solution of blue vitriol, or, better still, a crystal, allows blue, green, and yellow light to pass through it if it be thin, but when thick only blue. Analogous phenomena are shown by purple films of gelatine, and by a solution of chromium potassium oxalate. These are cases of increasing selective absorption where waves of certain colored lights can pass in some measure through weak solutions or thin layers, but are at last completely stopped or absorbed by layers of increased thickness.

The Chromatic Circle.—I can dwell no longer on this very convenient mode of arranging an orderly sequence of colors than will just suffice to explain the uses which I shall have to make of it in subsequent lectures. The disk, of which our chromatic circle is the boundary, may be regarded as the base of a color cone, differing from that of Von Bezold in the approximately correct angular positions accorded to the several colors which find place in the circle.

I have followed in the main the construction given by Rood to the chromatic circle, but I have not adopted his nomenclature, except in a few cases, while I ought to have used capital letters to indicate the hues corresponding to the three primary color sensations, and have emphasized these and their complementary secondaries by joining them by diameter lines of extra thickness. (See diagram.)*

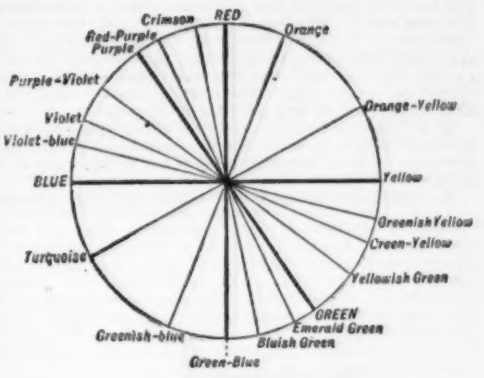
Professor Rood determined the position of his normal red ("spectral red"), in a pure solar normal spectrum, and found it to be at 285, when the space between the fixed lines A and H was divided into 1,000 equal parts. Similarly his normal green is situated at 600, and his natural ultramarine at 785. His normal blue was taken at a point nearer the blue-green side of lapis-lazuli than that which I am able to accept. The three primaries I adopt are approached very closely in hue by the following pigments:

Crimson vermilion, for the red.

Emerald green with a trace of chrome, for the green.

Pure natural ultramarine, for the blue.

Putting aside the questions of purity and of brightness, each one of these three primaries is neutralized, so far as hue is concerned, by one of the three secondaries, thus—Red, by green + blue, or sea green; green, by blue + red, or purple; blue, by red + green, or yellow. Thus the pairs, red and sea green, green and purple, and blue and yellow, are what we call complementary colors, and united produce in each instance white. But, of course, there are an infinite number of



complementaries, the pair of colors at each extremity of every diameter of the circle having the right to be so designated. This, however, is a subject to which we must return in the next lecture, and so I wish now to confine our attention to two other matters—the angular intervals which separate the selected colors to which I have assigned names, and the doctrine of chromatic equivalents.

In the earlier attempts at arranging colors in a circle, an inaccurate and quite arbitrary plan was adopted of placing the three primaries at three points equidistant from one another. Suppose, however, that we obtain a normal diffraction spectrum, and merely glance at the position which our three selected fundamental hues occupy, it will be immediately obvious that the green is separated from the blue by a smaller interval than that which divides it from the red. And if we take the numerical differences obtained by comparing the wave lengths of the three fundamental hues, we shall arrive at the same conclusion. It is by fixing the spectral position of the pigments which most nearly approach these fundamental hues, and consequently learning their corresponding wave lengths, that we are enabled to assign approximately correct angular positions on our chromatic circle to the pigments in question. For the practical purposes we now have in view, the allocation of proper positions to our most characteristic pigments is the problem which our chromatic circle is intended to aid in solving.

Chromatic Equivalents.—Still dealing with pigments, we may ask, What areas of complementary pigments neutralize one another's hues? and—What are the equivalents of the three fundamentals as represented by the corresponding pigments? We can answer these questions with a sufficient degree of accuracy by means of rotation experiments with sectors suitably painted, using such areas of the different pigments as shall produce a neutral gray. Here is one set of results thus obtained with a circle divided into 100 equal degrees:

Red (crimson vermilion)	38·3°
Green (emerald green and chrome)	35·0°
Blue (natural ultramarine)	26·7°

On rotation these sectors produced a gray equal to that derived from 25° white (paper) with 75° black (paper). This large quantity of black shows how great a stride toward darkness is made when pigments (owing their colors to selective absorption) are used. From the above chromatic equivalents, reduced to their simplest expressions, we get the following equations:

Red = 12.		Green = 11.		Blue = 9.		
Red	+	Green	=	Yellow	=	23
Green	+	Blue	=	Sea green	=	20
Blue	+	Red	=	Purple	=	21

It will be remembered that Field, by the erroneous method of combined absorption through colored glasses, found the following equivalents:

Yellow	= 3
Red	= 5
Blue	= 8

And on these equivalents, widely as they differ from the truth, have been based those calculations generally current among colorists as to the proportionate areas of colored surfaces by which a chromatic balance and the so-called "neutralized bloom" are to be secured.

I may add here that Rood, employing a red paper of moderate brightness along with emerald green and artificial ultramarine, obtained for these pigments the following values in degrees:

Red = 50. Green = 31. Blue = 19.

The neutral gray these sectors produced on rotation was matched by the rotation mixture of 13 of white (paper) and 87 of black (paper). These values differ, as one expected they would, from those I previously gave, but they lend no support to the figures of Field. On the contrary, they correspond to the ratio—

Yellow, 81: red, 50: blue, 19;

while Field's figures, multiplied by 10 for the sake of easier comparison, are:

Yellow, 30: red, 50: blue, 80.

* This diagram is reproduced from "Color," p. 91 (Cassells).

IMPROVED OPHTHALMIC REFRACTOMETER.

THE proper assistance for defective or for failing vision has to be determined in all cases, even when the spectacles are required for reading only, by first testing the distance vision. The refractometer, says *Engineering*, determines the correction only for distance vision (refraction), *i. e.*, the error for parallel rays, and is therefore distinct from the optometer, which is an instrument for measuring the *limits* of distinct vision.

An insight into what constitutes errors of refraction will enable us to understand the utility of the refractometer. The eye as an organ of vision is essentially an optical instrument. It follows that if the "principal or real focus" is not formed exactly on the retina, but either in front of it or behind it, there exists an error, which is called "error of refraction."

If the real focus is formed in front, that is, before the retina is reached, the eye is too deep or the refraction too short. The error here is (+), and the correction has to be minus (—). If, on the contrary, the real focus falls behind the retina, that is, as if it were outside the eye itself, the eye is not deep enough or the refraction is too long. The error is here minus (—), and the correction will have to be plus (+).

If we take the same value for these opposite signs we shall obtain zero, or a true refraction in the eye. For facility here, we shall term these errors "errors of depth."

We next have to direct our attention to the manner in which the principal focus is produced, be it formed on the retina, in front of it, or behind it; because if that focus is not homocentric, but more or less extended or elongated in any of its meridians, we then have an error of symmetry which can also be plus (+) or minus (—). We shall here call these errors "errors of symmetry."

"Errors of depth" are corrected with the aid of spherical lenses, convex lenses that add to or concave lenses that decrease the natural convergence, and errors of symmetry are corrected with concave cylindrical lenses that *neutralize* or convex cylindrical lenses that *utilize* the natural symmetry. With regard to these last lenses, the setting of the cylinder's axis to the required meridian, which may be at any angle, must be carefully observed; hence the necessity for the cylindrical lenses to rotate upon their central axes.

The above errors may exist separately or be associated. We now see that for the diagnosis of errors of refraction it is necessary to have four series of trial lenses of different degrees. One representing spherical curves concave ($s-$), one spherical curves convex ($s+$), one cylindrical curves concave ($c-$), and the other cylindrical curves convex ($c+$).

Having explained what constitutes "errors of refraction," and the series of lenses necessary to their correction, there remains to describe the process in general use when determining these errors. It consists, first, of an examination with the ophthalmoscope or with an optometer. Each one of these examinations gives only approximate results, that require to be proved, which is done in the following manner:

In a room of suitable size there are exposed types of graduating letters, that represent the visual acuity for their respective distances.

The subject standing at a certain distance from those letters, the operator presents successively before the eye the lens of the degree obtained by the result of the above examination, and that of the degree stronger and weaker, to arrive at the exact number.

When dealing with errors of depth, the verification does not offer much difficulty, but with errors of symmetry the verification becomes more difficult, and sometimes very fatiguing, as the operator previous to presenting the lens to the eye has to assure himself of the cylinder's axis and dispose the lens between his fingers in the particular position requisite to the case under examination, the same care having to be repeated with each lens. For these errors it frequently occurs that the proof occupies two and even three hours of time and exercise for a single eye.

To render the trial of the various lenses more easy and rapid, Mr. A. Fournet of 18 Bentinck street, Welbeck street, London, has invented the compound ophthalmic refractometer here illustrated. This is an instrument by which any lens, or any required combination of lenses, can be placed before the patient's eye while he sits comfortably in a chair, and directs his gaze to the test types at the other side of the room.

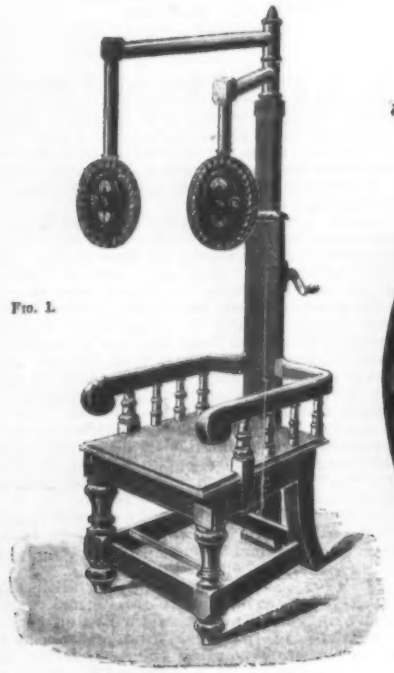


FIG. 1.

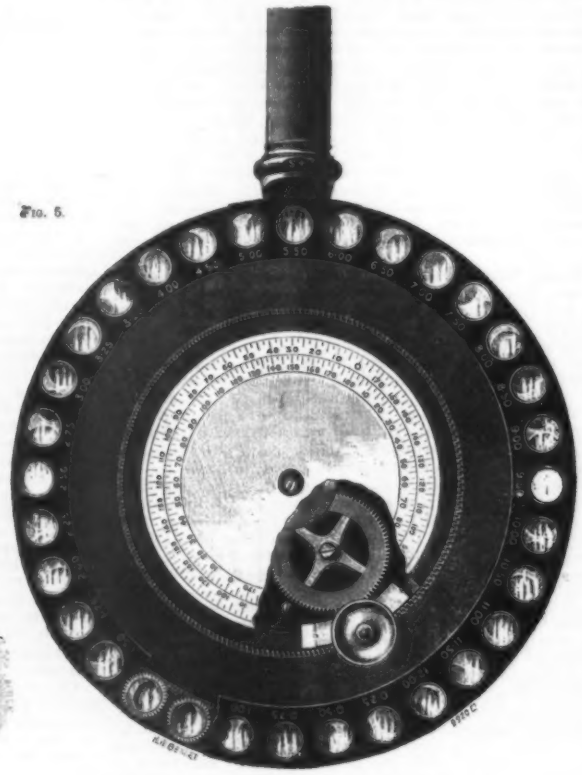


FIG. 5.

FIG. 2.

FIG. 3

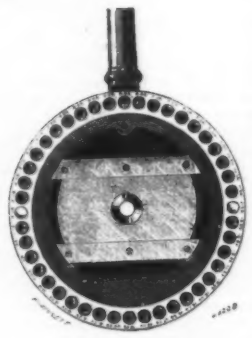


FIG. 4.

FOURNET'S COMPOUND OPHTHALMIC REFRACTOMETER.

The lenses can be set at any height and applied to either eye, while the cylinders can be turned to the desired angle with absolute accuracy. The patient seats himself in the chair (Fig. 1) and makes himself comfortable, so that he can give his entire attention to the matter in hand. He obscures one eye by means of a spectacle frame having one black glass in it, leaving the other eye free. The lens frames are then adjusted to the right height by the crank angle at the back of the pillar, so that the horizontal diametrical line is level with the eye.

There are two frames. One contains convex spherical lenses, and the other concaves. To each frame there can be applied a removable ring of lenses. Two rings are provided, one containing convex cylinders, and the other concave cylinders. Thus each set of spherical lenses can be combined with either set of cylindrical lenses.

The stem or stalk of each frame (Figs. 1 and 3) ends in a fork which is fixed to a dished metal plate having two empty sight holes (Fig. 3). On the opposite side of this plate are two guides (Fig. 4), between which there moves a slide having a boss on its opposite face (Fig. 3). The dished plate is slotted to allow the slide with its boss to move in the guides. Pivoted to a stud on the dished metal plate is a second circular plate with the central part cut away (Fig. 4), and around this plate is fitted, free to revolve, a ring containing spherical lenses spaced around it. The second plate can be secured by a catch in any of these positions, that is, it can be fixed concentric with the dished plate (Fig. 4) or eccentric to it to the right or left (Fig. 3). In the former case, vision is blocked through all the lenses exept the two opposite the sight holes. The spherical lenses can, however, be pushed aside either way by the handle shown at the lower part of Fig. 3, to leave the cylindrical glasses alone before the sight hole.

Similarly, the cylindrical lenses can be moved away by the central slide to leave the spherics alone.

As already stated, the cylindrical lenses are fitted in removable frames which can be applied to the frames just described (Figs. 2 and 5). Each lens is fixed in a ring capable of revolving in holes formed in two plates, one at each side of it. This ring has teeth on its periphery (Fig. 5), and these teeth engage with a ring toothed both on its inner and outer peripheries.

By means of a pinion and milled head the ring can be turned and with it all the lenses, setting their axes at any desired angle to suit the sight of the patient. This angle can be read off on a rotating card which is also geared to the pinion. The greater part of the guard and the gearing is hidden by a cover plate (Fig. 2).

By the aid of the instrument the manipulation of the series of lenses is so rapid and precise that there is no reason for a severe diagnostic examination, the refractometer giving to the operator exceptional ease and command in combining the different classes and powers of lenses, to wit, the drawing of one upon another, the easy interchangement between each other, and the ever ready and orderly power of their regular progressive displacement. So soon as it is known that the eye under examination is plus (+) or minus (—), the set of disks of the opposite sign is brought into requisition, and the operator in a few minutes has the advantage of bringing before the eye any two, or both series of lenses, which he can compare, mix, and change in all possible positions, with a most perfect mastery.

The apparatus obtained a silver medal at the Paris exhibition.

MEDICINAL SOAPS.

FROM very early days the possibility and advantages of treating the skin with remedies applied through the medium of soap have been recognized and appreciated. In the first place the customary, frequent, and regular use of soaps insured the more or less continued application of the remedy; and, secondly, the latter could often be employed, in this way, at times and on surfaces where the use of an ointment was inconvenient or unsightly. Further, the thorough cleansing of the skin is often an important indication in the treatment of certain morbid affections of that tissue, and it was seen that it would be an advantage if the cleansing and medicating processes could be simultaneous. Once more, in the treatment of minor affections of the skin of the face, not sufficiently severe to necessitate staying indoors, it is manifestly undesirable to order the surface to be plastered with ointment.

There are certain considerations, however, which had and have to be borne in mind, in adopting the use of medicated soaps. First of all, a pure base must, for obvious reasons, be alone used. The presence of a remedy possessed of marked value in skin diseases would not be sufficient to annul the irritating and aggravating effects of an impure and alkaline soap base. The latter would cause roughness and desquamation of the epidermis if applied continuously to a healthy skin, and therefore can scarcely be expected to exercise a curative effect upon a more or less diseased surface. Hence it is essential that medicinal soap should be made from ingredients of good quality, and that they should be neutral and unirritating.

Again, it must be remembered that the application of soap to the skin is generally of short duration, so that in the ordinary way the medicinal soap must not be expected to produce as prompt or as powerful an effect as an ointment which is kept *in situ* for hours. For this reason soaps are generally only prescribed when the skin has been restored to a relatively healthy condition, and it is desired to prevent a recurrence of the morbid phenomena, or in slight cases of cutaneous eruptions, etc.

A more pronounced and rapid effect may also be attained by using the soap on going to bed, and allowing the lather of the soap to remain on affected parts during the night.

The first medicinal soaps to be prepared contained

TAR,

the excellent effects of which in chronic skin diseases were early observed. These tar soaps were not pleasant looking nor agreeable to use, having a powerful odor suggestive of gas works, and though useful and effective enough, were not regarded with much favor by the patient.

With the development of antisepsis a number of substances were introduced which were equal therapeutically to tar, and without its pronounced disadvantages. One of the first of these was

CARBOLIC ACID,

and this was also made into soap containing a variable amount of the agent up to 25 per cent. The latter, specially suitable for surgeons' use, can be prepared by mixing in a warm mortar 75 parts of powdered stearin soap with 25 parts of pure carbolic acid and pressing the product in toilet soap forms; it lathers well and only slowly dissolves. A soap containing even so much carbolic acid can be used without any injurious results for the hands, though, of course, it is not advisedly adopted for general use.

Even carbolic soap, though a great improvement on tar soap, is not altogether an ideal article. Although still largely used, its pronounced odor is by no means generally admired, and in many instances is strongly disliked.

The number of medicinal soaps now made is very large; hardly a single antiseptic is introduced which is not at once incorporated with a soap base, and recommended for the treatment of skin affections. It may be interesting to describe some of them, and to mention the particular cases in which they are believed to be indicated.

As a, if not the, most important of modern antiseptics thus used,

SALOL

may be given a prominent place. As a dusting powder it has accomplished some very striking cures of skin diseases of the most obstinate type. Specially also it has been found unequaled in cases of sycosis parasitaria, where all other remedies had previously failed. As this disease may be, and undoubtedly is, contracted at barbers' establishments by means of razors and accessories, it was proposed that a salol shaving soap should be made for use in such businesses as a cure for and preventive of sycosis.

THE SOAP IS PREPARED

in two stages, the first being the manufacture of the base. This is carried out as follows: 1 lb. of beef suet is melted with ½ lb. of cocoanut oil, and allowed to cool to 120° F.; then 14 ounces by weight of 18 per cent. caustic soda solution and 2¼ ounces of 24 per cent. caustic potash solution are added and stirred together at a gentle heat for half an hour, or until a homogeneous mixture is formed. Perfume is now added, consisting of oil of caraway 40 minims, oil of bergamot 50 minims, oil of lavender 30 minims, oil of thyme 20 minims, and essence of mirbane 6 drops. While the mass is still warm, 1 ounce of finely powdered salol is added, the whole heated sufficiently to melt the antiseptic (to 113° F.), and well stirred. It is then allowed to cool, cut into pieces of the desired size, dried partially in the air, and wrapped in tin-foil.

The salol soap powder is made by mixing 35 ounces of finely powdered stearin soap with 1 grain of coumarin, 5 drops of oil of bergamot, and 2 of oil of wintergreen; 2 lb. of this base are mixed with 1 ounce of finely powdered salol.

Another substance largely used in skin diseases is

SULPHUR,

and this is also made up into soaps of various degrees of efficacy. The best contain about 10 per cent. of very finely divided sulphur, and are perfumed, as the element gives a rather unpleasant smell to soap when used alone. Various combinations of tar, of naphthol or of iodides, etc., with sulphur are also made which are commended for various cutaneous disorders, pimples, comedones, freckles, etc.; sulphur, when continuously applied, tends to produce a clear and healthy complexion.

ICHTHYOL

is another preparation, which, having earned a great reputation in the same class of remedies, has also been largely used as soap containing 5 per cent. of the sodium sulphichthyolate. In this form ichthyol displays effectively its great power over affections due to or associated with a dilated condition of the vascular system. The soap is particularly prescribed in the treatment of eczema and rosacea, it has been found to exert a marked beneficial influence upon redness of the skin, and particularly the condition known as "red-nose." This latter property is also ascribed to a soap containing camphor (about 5 per cent.), which is a mild stimulant to the skin.

Another series of medicinal soaps is made, containing such

ESSENTIAL OILS

as are possessed of antiseptic virtues. Among these may be mentioned wintergreen, pine and eucalyptus oils, while also thymol and terebene might be placed in the same class. The first three may perhaps be considered more as hygienic toilet than medicinal soaps; they are particularly suitable as preventives of freckles, pimples, tan, chaps, etc., and for improving the complexion. The thymol soap (2-5 per cent.) has been employed to sweeten suppurating wounds and ulcers, and to treat herpes and other allied diseases; it is a mild and agreeable antiseptic application.

BORACIC SOAP

containing borax or boric acid is attracting attention. The marked cleansing powers of borax have been long recognized, as well as its utility in restoring health and vigor to the diseased epidermis. The soap has already been considerably employed as a toilet remedy for itching, freckles and eruption, as well as for securing a clear and healthy complexion. At the same time it forms a splendid shampooing soap, cleansing the hair from excess of fat, from dandruff, etc., in a thorough and expeditious manner.

There seems to be no unsurmountable difficulty in the way of the introduction of almost any substance into a soap, even the most unlikely.

MERCURIAL SOAPS

are made by saponifying mercurial ointment. Thus, 10 ounces of mercury are gradually incorporated with 2 ounces of mercurial ointment until globules are no longer visible with a lens, then 1 lb. 2 ounces of soap (powdered) are added, and 2 ounces of lard.

A soap can also be made to contain say 5 per mille of sublimate, which is useful in the treatment of secondary syphilitic eruptions, of scabies, and of parasitical affection. Being free from unpleasant odor, it is preferable to some other antiseptic soaps. A preparation of this kind would also seem to be useful for cleansing the coats of domestic animals.

These are some of the chief of modern medicinal soaps which have been found useful and beneficial in the hygienic treatment of the skin.

It is not, perhaps, desirable to needlessly enlarge the number of soaps which are indicated in the same class of diseases, yet there would seem to be room for experiments in this direction which must be carried on as joint work by the manufacturer and the medical practitioner.—*Monthly Magazine.*

SEBORRHŒA AND BALDNESS.

IN *Gaillard's Medical Journal* for May, 1890, Dr. George T. Jackson gives an interesting account of that very common and annoying affection, seborrhœa. This disease, while it causes little actual physical discomfort, is one which may interfere decidedly with the personal loveliness and, *propter hoc*, the mental quietude of both doctor and patient, for it disfigures the face and causes dandruff and baldness. It is well for doctors to know all that there is to be known about seborrhœa. There are, we are told, two kinds of seborrhœa, viz., the oleaginous and the dry. The oily form usually occurs most markedly upon the nose and forehead, and it shows itself unmistakably and frequently on warm nights, at social gatherings, forming a greasy coating upon the nose which the most careful powdering fails to disguise. Acne and comedones may complicate it.

But the dry form is the most common, and the one we are oftenest called upon to treat.

This most usually appears in the form of yellowish or grayish fatty plates or masses, which, when taken and rubbed between the fingers, impart a greasy feel. Upon the scalp it constitutes one form of dandruff. Here it may be general, involving the whole scalp, or it may locate itself in certain places in a more pronounced way than in others. The hair is dry, and after a time, the seborrhœa continuing, it begins to fall, and at last baldness is established.

The fact that dry seborrhœa is a cause of dandruff and baldness gives to it its special importance.

Ordinarily, this form is not accompanied with any redness or inflammation. But there is a second variety in which a varying amount of dermatitis is added to the seborrhœa. Then there will be a rim of redness about the fatty crust, and when the crust is removed from the skin, the underlying part will be seen to be red. In this variety there will be far more decided itching and burning than in the preceding variety. It is to be noted that although the skin is red, it is always dry and never infiltrated, in these respects differing from eczema.

While most authorities have held that seborrhœa is a disease of the sebaceous glands, Unna has asserted that it is in fact due to an involvement of the sweat glands, and that seborrhœa sicca is in reality a seborrhœal eczema. This view is not yet an accepted one.

Various attempts have been made to find microbes which could be considered the cause of seborrhœa. The parasitic theory gains some plausibility from the fact that antiseptics are the best curative measures, and also from certain experiments in the inoculation of dandruff. There is enough merit in this view, also, to justify the person who does not wish to get bald prematurely in having his own brush and comb at the barber's. And it may yet be that antisepsis in the barber shop is to be the preventive of premature loss of hair.

The treatment of seborrhœa is simple. Dr. Jackson recommends sulphur.

After the removal of the crusts by means of any oil, or grease (this should be done the first thing, whatever remedy is chosen), the sulphur is to be applied in the strength of a drachm to the ounce, either suspended in sweet oil, cotton seed oil, or vaseline. It should be well rubbed into the scalp, and the application repeated every night for one week. It is well to advise the patient to wrap his head up in a towel or to wear a night-cap. This for the benefit of the housekeeper, who will thank you for saving the pillow cases. After one week's use of the sulphur, the head is to be washed with soap and water, and the oil, or salve, immediately reapplied. During the second week it will be sufficient to make the application every other night. Thus the treatment is to be continued, the number of applications being reduced until they are made but once a week. By this time the disease will be cured. The patient is to be cautioned that relapses are likely to occur, and therefore it will be best for him to keep a supply of his oil, or salve, on hand, so as to attack the trouble as soon as it shows itself.

Mercurial ointments are almost equally efficient; and the Lassar treatment, which has already been described in these columns, is also said to be a good one. —*Medical Record.*

[MEDICAL AGE.]

THE ROLE OF THE MICROBE.*

By A. R. SMART, M.D.†

THE discovery of the micro-organisms known as bacteria, or schizomycetes, was made over two centuries ago. For a long time but little was known of these bodies. About forty years since, they began to be mentioned in connection with various diseases, and a causal relation was assigned them; but it is only in the last two decades that the microscopist has so far outstripped the chemist in the race of discovery. A world of microbes hitherto unknown has been brought to light by the microscope, and one after another has been identified with different forms of disease and destructive processes, and in many cases been declared the chief causal factor. So far has the tendency of medical investigation extended in this direction, that scarcely a disease exists that is not asserted to have a bacterial origin. Rheumatism, cancer, mumps, serous inflammations, pneumonia, fevers, inflammatory states, acute and chronic, of bone, gland, muscle, or nerve, are all said to arise through bacterial agency, and the height of the bacterial craze seems attained by a recent writer who declares anal fissure to be a parasitic disease. I suppose the division or stretching of the sphincter, which so promptly cures, must destroy the offending bacteria. Sad indeed is the parentless condition of that malady in these days which cannot show a microbic genealogy. The old notions of heredity, impaired vitality and nutrition, diathetic influences, the chemistry of nutrition involved in cell activity, etc., are in danger of being forgotten or ignored. Probably no subject has occupied the medical mind during the last few years so fully as has the germ theory of the etiology of disease. Old ideas have been relegated to the rear. Pathology is becoming a study of the life history of microbes, and therapeutics a search for agents to kill them. When this has been accomplished, the simplicity of homeopathy will be surpassed; and all required will be to identify the microbe and destroy him. This Utopian idea of the practice of medicine is not, however, likely to be realized. It is probable that much now so confidently assumed regarding the action of these organisms and their relations to the tissues of the human body will ultimately be abandoned, as much has been already renounced. Much praise is due to the patient, toiling workers in this field, but the subject is a very difficult one.

Our knowledge of these bodies and their habits is yet in its infancy. The same is true of the nature of protoplasmic action in the cell, constituting the phenomena of life. What has been attained may prove a foundation for a complete superstructure, but is far too fragile and insecure a basis on which to rest the important structures of pathology and therapeutics. Since we are daily urged to accept as final the conclusions of some germ theorist, let us briefly notice some reasons *why* we should hesitate to accept without reserve the bacterium as so important a factor in the disease problem.

The group of schizomycetes or bacteria, one of the seven classes of vegetable fungi, are of universal distribution, upward of 200 having been discovered as possessing an individual identity; and the returns are not yet all in. They swarm about in the food we eat, in the water we drink. The cavities of the body to which air has access contain them. It has been asserted that they are found in closed cavities, and formerly it was claimed they could be found in healthy blood. This view is not now entertained. Of the whole number known, few are considered harmful or of importance as disease producers. Not only are they harmless, but they are of essential value in the part they act in life processes. Without these micro-organisms life could not go on, either in the animal or the vegetable; the destructive metabolism begun in the animal cell is furnished by the microbe. They are factors of the greatest importance in the nutritive processes of plants and animals, both as parasites and saprophytes; they are active in resolving into simpler elemental forms any organic material within their grasp and which they require for their nutrition. They consist of masses of protoplasm inclosed in a cell wall, and possess properties common to cell life—power of nutrition, reproduction, and excretion of effete material. The blood, cerose fluids, and tissue cells of the body are inimical to these organisms, and either destroy them or prevent their growth. Prudden says considerable numbers of pathogenic germs may be introduced into normal blood and they will disappear in a short time. The blood serum of different animals seems to possess different germicidal power. The serum of the dog exceeds that of the rabbit. Certain conditions of a tissue or special periods in its growth afford a better soil to bacterial growth, as illustrated by the rarity of ringworm after sixteen, or tubercular joint disease after the age of puberty.

Different species again require different soil for development. But few of our infectious diseases are communicable to animals. Again, Loeffler found in one out of twenty normal fauces a micro-organism which caused rapid and fatal septicæmia in animals. Another has cultivated a microbe found in the pharynx of healthy persons as well as those suffering from scarlatina and diphtheria, and apparently identical with the alleged diphtheritic bacillus, yet inoculation of animals with it produces no untoward results. More than a score of microbes have been described whose home is in the alimentary tract; here they work various and important changes in the digestive processes. Some induce putrefactive changes in the nitrogenized matters, but only in the later periods of digestion. If the process is normal and rapid, no bacterial activity will be displayed. If slow and imperfect, bacteria will thrive with the development of toxic principles. In like manner pathogenic bacteria may incite a series of chemical changes in the tissue cells, but not until vitality and normal resistance have been impaired. It is not certain whether the phenomena incident to the growth and development of the microbe result from the microbes themselves or from the chemical poisons generated by their growth and by the cell destruction. About forty toxic principles are known of this character. Brieger says the chemistry of bacteria stands in most intimate relation to the diseases with which they are associated. M. Peter remarks that cholera may be much better explained by ptomaine poisoning than by the comma bacillus. Fluids, sterilized, have in a number of experiments been found to produce the same results when thrown into the blood or peritoneal cavity as when they held the living organisms, the severity of the symptoms being in proportion to the amount used. It has been shown that solutions in which the micro-organisms had been destroyed by heat were still capable of setting up purulent inflammation. Chamberland and Roux found, by injecting solutions in which bacteria had been destroyed, that the animals were made resistant to inoculation by the corresponding microbe, and that efforts to discover the chemical substances which thus prevent the development of the special germ in question, and confer upon the body immunity from its action, have failed thus far.

In a recent article in the *British Medical Journal* Mr. Hankin claims to have extracted from anthrax culture fluids an albumose which conferred this protective influence. It is known that saprophytic microbes in the intestinal canal generate in their growth substances that arrest their further activity. The generation of leucomaines in the metabolism of albuminoids without bacterial agency is now generally recognized; this in connection with the proved fact that the symptoms produced in connection with certain microbes can be caused without the intervention of the living germ seems to show the agency of some chemical substance yet undetected.

Roscoe says the symptoms of infective disease are no more due to microbes than alcoholic intoxication is due to the yeast cell. The experiments made with jequirity bean are interesting in this connection. An infusion of the bean, after standing a time, was found to contain certain special bacteria to which the action of the infusion was ascribed. These were cultivated through several generations and yet retained their specific properties. Dr. Klein found that an infusion carefully made to prevent contamination, and used immediately, while producing the characteristic inflammation of the eye, produced no change in sterilized peptone solutions. It was found that the spores of this bacterium would bear boiling for a few minutes. Dr. Klein boiled an infusion full of bacilli and spores; sterile test tubes inoculated with this were teeming with bacilli after forty-eight hours, but no amount would induce inflammation, showing that the heat had destroyed the principle which caused inflammation, and that it was not the bacilli. It is claimed that an inherent ferment exists in the tissues in health capable of inciting structural change when the closest scrutiny reveals no micro-organism. Brunton says facts seem to point to ferments or enzymes by which tissues are built up and pulled down. The experiments of M. Roussy in-

* Read before the Ohio State Medical Society, June, 1890.

† Professor of physiology in the Northwestern Ohio Medical College.

dicate that the soluble chemical substances found with micro-organisms are very likely the cause of the phenomena produced rather than the microbes.

Many evidences exist to show that all cells or biological units by their vital activities elaborate soluble ferments or principles of the greatest importance in the processes of nutrition, and of whose nature and mode of action we know but very little. These are questions intimately related to the ætiology of infectious diseases and to the immunity acquired by prior attacks.

The doctrine of cell antagonism, while a well established physiological fact in which the phagocytic action of leucocytes is universally admitted, is not conclusively proved as regards micro-organisms. Metschinkoff and his followers claim that not only leucocytes, but the fixed connective tissue cells, and the giant cells of the liver and lungs, are most active phagocytes. The recent experiments of Nutall, Bechner, and Prudden show that the blood serum and serous fluids possess a germicidal power exceeding the phagocytic property of blood or tissue cells—a property in some way dependent on their albuminoid constituents, and of sufficient importance, as Prudden remarks, to call back the attention of the therapeutical adventurers from germicidal warfare to what appears a natural defense of the organism against bacterial invaders, viz., a healthy condition of the blood. Conditions have much to do with bacterial activity. It has been noticed that bacteria that had no effect on healthy animals excited disease and grew and developed in those slightly deranged. By increase in numbers alone the body resistance may be overcome, and even non-virulent microbes in sufficient numbers may cause death.

It is also true that similar groups of disease may be associated with wholly different microbes; and that harmless organisms may, under certain conditions, acquire virulent properties, is probable. From what has been said, it would seem many other and more important elements of disease exist than micro-organisms. Not only is it not proved that bacteria are the prime causes of epidemic and infectious diseases, but their existence is not satisfactorily accounted for. It is by no means certain whether microbes are the cause of diseases in which they are found or only scavengers incident to the process. We know so little of their relation to the bodily tissues that we cannot tell why so many times pathogenic microbes do no harm, or how they disappear from the blood or in the glands. It is a question whether without a primordial generating cause the microbes of a specific disease would exist at all. In the language of Semmola: "The error of the day is in considering bacteriology the key to all pathology. Doctors conclude that the microbe is the cause of the condition, whereas it is many times only the effect." Certainly it is fully as important to study the field of culture as the microbe itself.

It was in the field of surgery that the germ theory first won its laurels. For a long time Listerism and strict antiseptic details held sway. One feature after another has been abandoned until the views of fifteen years ago have undergone very radical change. One of the first notions abandoned was peritoneal antisepsis. Now few, if any, advise antiseptics in abdominal surgery—at least in the peritoneal cavity. Bantock uses no antiseptics whatever, not always boiling the water used. He says "water fit to drink, or for household use, is good enough for surgical use." Yet his mortality without antiseptics was four per cent. against an average of 17 per cent. with antiseptics. Lister himself has abandoned the spray, and many of the devoted adherents of Listerism have given up details which were once thought to be essential.

Once it was thought beyond dispute that pus formation was solely and only caused by bacteria. The dictum "*no micrococci, no pus*" was accepted as final. Dr. Holtzman, an enthusiastic bacteriologist, says in the *Medical Record* for May, 1890, that pus cocci are present nearly always, but the axiom *no suppuration without micro-organisms* is not strictly correct, and the question is yet an open one. M. Steinhaus, in a long series of experiments on dogs, cats, Guinea pigs, and rabbits, refutes the idea that microbes are necessary to the formation of pus. Although staphylococci are generally found in acute suppuration, yet it has been shown that subcutaneous injection of pus cocci caused no suppuration. In cases of subcutaneous lesions, injections into the cellular tissues or into the veins of pus cocci were shown to have no tendency to collect about these spots and form pus. Rinne found that also pathogenic bacteria rapidly lose their virulence in the blood.

Recent experiments have shown that chemical agents, traumatism, and similar causes, may excite suppuration without the presence of microbes, and that the pus cocci often fail to set up suppuration when injected into the tissues. In dry gangrene without open lesion no bacteria are found. Dr. Hamilton, in an address before the Surgical Section of the British Medical Association, says pus in closed cavities does not contain the characteristic microbes of acute suppuration. This is why pus under these conditions produces little or no disturbance; when exposed to the air and decomposition begins with the development of microbes, then the micrococcus finds the congenial soil. Rinne says that ptomaines and the generation of chemical poisons have an intimate relation with the suppurative process.

In normal blood micro-organisms do not exist, and in view of the marked germicidal action of the blood and tissues, the theory of Verneuil, that "microbes remain latent for years in tumors or in the cells of connective tissues or serous structures," seems far-fetched and doubtful. The most radical germ theorists admit the influence of conditions; bacteria which cause septicæmia in house mice are said to be inert in the field mouse. The germs of splenic fever are little destructive to carnivora. Concentration in one spot, and above all the condition of tissue cell, is important. It is said the benefit derived from nitrate of silver in purulent inflammation of mucous surfaces is because it destroys the weak cell on the surface that cannot risk bacterial invasion. It should not be forgotten that agents that can destroy bacteria can also kill or impair the tissue cells. To kill microbes with the weakest solutions of germicides compatible with the integrity of the tissues requires hours of contact. Carbolic acid of sufficient strength to disturb bacteria suspends the molecular activity of the cells and paralyzes nutrition. It is a pertinent query whether many of the antiseptics in daily use injure most the microbe or the tissue cell. In their struggle with microbic invaders the body cells may aptly appeal to the surgeon in the prayer of the bear hunter: "O Lord, if you can't help me, don't help the bear."

Experience has shown that germs collect but slowly from the air. Irrigation kills or washes them away and is no doubt useful. Dr. Lenger, in experiments on animals with small quantities of antiseptic agents in common use, found they very generally produced pathological changes in the viscera. He advises that all antiseptics be discarded in operations involving any of the viscera. We may never know the extent of the damage by the agents employed to kill micro-organisms, but that it is not inconsiderable is very probable. Is it not safer and fully as important to secure such a state of the tissues that germs will find no pabulum for their sustenance? It is only in contact with dead matter, or living organic material of altered or impaired vitality, that they can thrive. No question exists of the benefits which have followed the practice of Listerism, or antisepticism. Have good results followed the action of germicides, or has the greater care taken to remove all foreign matters, blood clots, etc., from the wound, to secure perfect quiet by the natural and infrequent change of dressings, the free drainage keeping the surfaces dry, with all the painstaking minutiæ of antiseptic methods, been responsible for the improvement? That bacteria may set up putrefactive changes, three factors are essential, viz.: Organic matter, dead or devitalized; heat and moisture; material necessary to their growth. It follows that repair is aided by close adaptation, quiet, dryness of the surfaces, and absence of hot, moist surroundings.

The microbe just now attracting most attention is the bacillus tuberculosis. This, it is claimed, is the sole cause of tuberculosis. As a corollary follows the proposition that all forms of phthisis are caused by the tubercular bacillus. "All forms of phthisis probably are due to the presence of tubercle, and all tubercle is the outgrowth of bacillus tuberculosis; without the bacilli, however depraved the constitution, there will be no tuberculosis." The statement, contained in a recent address on pulmonary consumption, before the New York Academy of Medicine, fairly states the doctrine.

But is the bacillus the sole cause of tubercle?

The proof of this assumption rests upon the fulfillment of three conditions:

1. The bacillus must always be present in tubercle.
2. It must be found nowhere else.
3. Inoculations of pure cultures must always produce tubercular disease.

Have these conditions been established? In the dense fibrous form of tubercle found in the lungs no bacilli have been found in a large number of cases. In some instances they were found in the alveoli near tubercular deposits, but not in them. Prudden found them most often in disintegrating structures in the lungs and intestines, but found many cases of diffuse tubercle when no bacilli could be discovered. He also says the appearance of the parasite in the sputum is no evidence of the parasitic origin of tubercle. Draper says bacilli are not found in the early stages of tuberculosis. Gibbes found bacilli in only one of ten cases of reticular tubercle, which is said to be the typical form of tuberculosis. He also states that, in several cases of pulmonary tuberculosis with large cavities, not a single bacillus could be found out of several hundred sections examined. Many cases of like import might be adduced if permitted. Sternberg says it is probable that the tubercle bacillus is often found in the buccal and nasal secretions of healthy persons. Yet tubercular disease of these localities is rare.

Tuberculosis has been found associated with other microbes than the Koch bacillus, and has been produced by inoculation of cultures in the same manner. Courmont and others found a microbe, cultures of which produced tuberculosis by inoculation, and in which the microbe was found in the blood of the animal. An organism obtained by Manfredi caused by inoculation a deposit of grayish or yellowish gray nodules consisting of newly formed cells which began to soften in the center.

Again there is a question whether the symptoms produced by inoculation are the result of the bacillus or of some principle undetected in the cultures, as in the jequirity cases above mentioned. It is asserted that the identity of the lesions from inoculation, and those of human tuberculosis, is not established. There is much to show this.

Many authorities deny that the inoculated product is identical with either the reticular or caseous form of human tubercle. The animals experimented on are peculiarly liable to tubercle, but the tuberculous nodules found in the viscera of inoculated animals are not at all like tubercle found in the human lung, but are identical with those found by Ziegler as a result of mechanical irritants, and sometimes found in ordinary inflammatory deposits. Gibbes states he has never found the bacillus in the early stages of nodular formation, but only after it became caseous.

Much more evidence might be adduced in this direction did time permit, but enough has been mentioned to warrant doubts of the correctness of the doctrine that the bacillus is always the antecedent or even the necessary compart of tubercle.

It is common for the adherents of the bacillus theory to ignore or denounce all conclusions at variance with their opinions. In this manner have been treated the investigations of Spina, Formad, Gibbes, and many others, to which must be added the recent work of Aufrecht, a co-worker of Koch. Too formidable an array of skeptics exists to be silenced in this manner. We are led also to doubt from other considerations having a less direct bearing. If the bacillus is the sole cause of tubercle, it would seem impossible that it should not be more widespread than it is. It has been estimated that a phthisical patient will throw off 72 billions of bacilli each twenty-four hours. A case of acute miliary tuberculosis of the peritoneum, with no tubercle elsewhere in the body, was reported to a New York society not long since. The bacilli of leprosy and that of tubercle are not distinguishable, or with difficulty, from those of lupus. In the one case they produce no general infection, in the other it is found.

Many cases of tuberculosis recover spontaneously. Dr. Loomis found evidence of former tubercular deposits in the lungs of 60 per cent. of autopsies at Bellevue. A curious comparative fact is, only about 10 per cent. of cases treated recover. The theory, if established, has no value in prognosis. Bacilli are found in large numbers in cases with moderate or no physical signs, and which recover, and they have been found in small proportion in grave cases that terminated fatally; generally, they are in proportion to the extent of the destructive process, and not to the amount of tubercle. The *bacterium termo* has been found to diminish the proportion of bacilli in the sputum, presumably by destroying them, but without causing any improvement in the symptoms. Neither pathology nor therapeutics has gained anything by the alleged causal relation of bacillus to tubercle.

From what has been stated it must be inferred that the unity of phthisis and tuberculosis is not established. We are yet compelled to say, with Virchow, that "phthisis is a multifarious process, and that much more is necessary to understand it than to discover a microbe." The clinical history, and a study of the varying lesions of pulmonary phthisis, are irreconcilable with a belief in the unity of cause. We must still regard this disease as an inflammatory one, in the course of which tubercle or other forms of mal-nutrition may occur. Nothing has been, or is likely to be, found that will destroy the bacillus, that is not also destructive to the tissues. Not only has therapeusis gained nothing in the discovery of the bacillus, but it has probably received injury by diversion of attention from means and ways employed to strengthen the citadel against the approach of the enemy. Here again we must look for aid to nutritive conditions; the factors which give immunity in one case, or predisposition in the other, are of increasing interest to us. The strongest advocates of the bacillus doctrine admit the importance of conditions; some form of irritation or mal-nutrition is essential to furnish a soil for their development and growth. "Ay, there's the rub." It is not bacilli that are transmitted by inheritance, but impaired tissue, a lowered resisting power, and an increased susceptibility to morbific processes. Loomis says there is always a period of general impairment of nutrition which precedes bacilli infection. Dr. Marquay aptly says: "To cure mal-nutrition is to cure phthisis." The many cases of spontaneous cures have resulted from improved nutrition rather than from bacterial destruction. It is more important, in the treatment or prophylaxis of phthisis, to nourish phagocytes than to try to kill the bacillus—to strengthen the resistance rather than try to destroy the invader. We would not underrate the possible advantages that may come from the discovery of the tubercle bacillus, but as yet very little positive benefit has been derived; and until its relation to the tissues and to the disease in question are more fully established, we would counsel conservatism as in the case of other microbes considered. A condition of lowered vitality or impaired cell activity is necessary to furnish a nidus for their development. Without this they are of but little importance. Is it not wise to devote more attention to securing resisting cell power than to search for germicides? Is it wise to abandon the accumulated clinical experience of ages past, and enter on a fruitless chase after a microbe which may prove only an incident, and perhaps not an essential one, in a complex nutritive disorder?

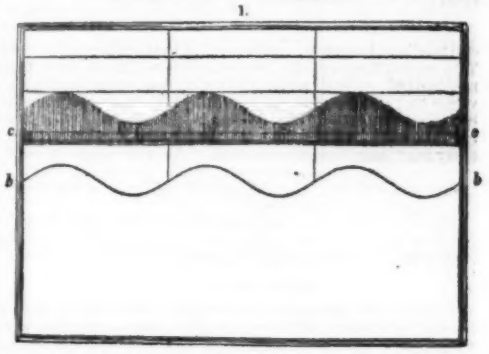
AN IMPROVED WAVE APPARATUS.

By JOHN T. STODDARD.

THE apparatus shown in the cuts was made several years ago for the purpose of demonstrating to my classes the formation of the compound curves representing the combination of two simple sound waves. It has answered its purpose so well that a brief description may be of interest.

The apparatus consists of a frame of whitewood, holding some 270 ebony strips whose tops are trimmed to a sinusoidal form (Fig. 1). The strips are 11mm wide,

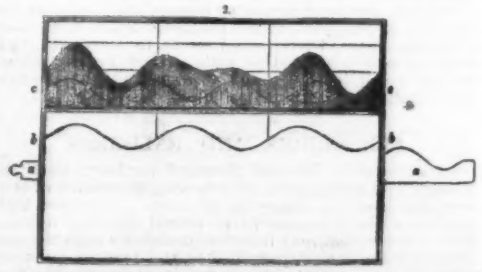
1.



about 4mm thick and from 23 to 31mm long. They are supported on a straight edge projecting 5mm from the back of the frame. Three simple waves having a wave length of 36mm and an amplitude of 4mm are represented. Vertical white lines mark off the single wave lengths, a line is drawn on the strips parallel to the edge on which they rest, and the "fundamental" is reproduced in the parallel curve drawn on the front board of the apparatus.

Wave forms cut out of thin board can be introduced below the strips (*a a*, Fig. 2), through a slit in the side

2.



of the frame, and raised by a simple arrangement at the back to a height which is sufficient to lift the strips from their supporting edge. This done, the tops of the strips assume the form of the combination curve,

while the white line on the strips reproduces the sinusoid on which they rest. As the fundamental is shown on the front board, one can compare at leisure the component curves and their resultant. The considerable wave length and amplitude of the fundamental as well as the thinness of the ebony strips render the combination curves fairly smooth. Since three waves of the fundamental are given, it is possible to produce a complete period of the curve representing the interval of the fourth [3:4], and one or more periods of all intervals expressed by simpler ratios. The effect of difference of phase is readily demonstrated, the straight line representing the "interference" of two elementary tones of the same pitch and intensity being sharply produced.

Smith College, February, 1890.

—*Amer. Jour. Science.*

THE GRAMOPHONE.

AMONG instruments for recording and reproducing speech and other sounds, the invention of Mr. Emil Berliner, of Washington, D. C., known as the gramophone, is remarkable as being distinct from the others in both form and principle. The gramophone was one of the early modern talking machines. It was nearly perfected when the latest form of phonograph appeared. Since that time it has been improved, and we understand that recent trials of the instrument in Europe have proved very successful.

Fig. 1 shows the recording apparatus; Fig. 2 the reproducer; Fig. 3 a print from an electrode taken directly from a gramophone record plate; and Fig. 4 shows the record of the vowels greatly magnified.

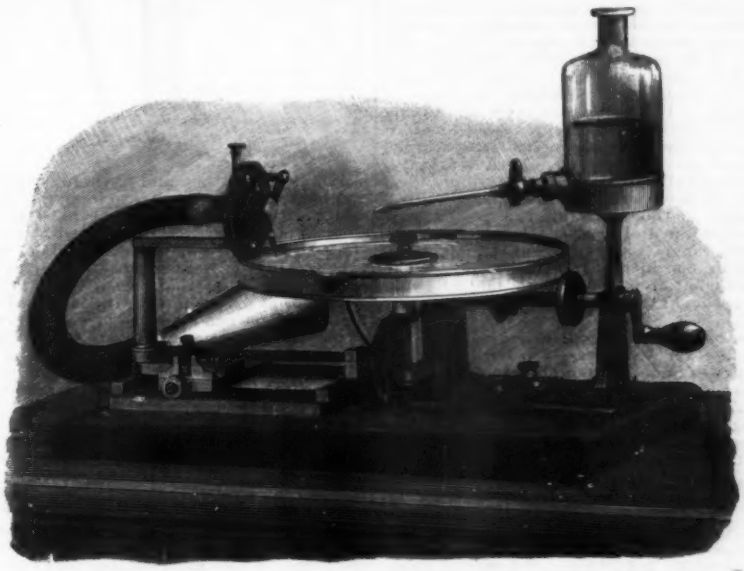


FIG. 1.—BERLINER'S GRAMOPHONE—THE RECORDER.

FIG. 3.—PRINT FROM SECTION OF GRAMOPHONE PLATE.

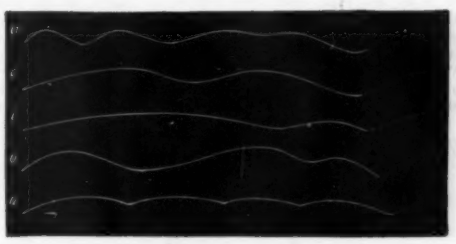


FIG. 4.—MAGNIFIED RECORD OF THE VOWELS.

In this machine a central apertured disk of zinc is used for receiving the record. The disk, which is covered with an extremely thin film of wax, is mounted on a vertical spindle within an etching trough which revolves with the spindle. The recording stylus, the diaphragm and the mouth tube are mounted on a carriage, which is moved toward the center of the zinc disk by a screw, taking its motion from the spindle carrying the disk. Motion is imparted to the record disk by a friction wheel on the horizontal shaft at the right of the engraving. This shaft is provided in the present case with a hand crank by which the plate is revolved. The same shaft is also provided with a pulley for receiving a belt from a suitable motor, when it is desired to operate the machine by power.

As the record disk is revolved, sounds uttered in the mouth tube cause the diaphragm to vibrate, and the stylus is moved in a direction parallel with the face of the record surface, forming in the wax film a sinuous line representing the sounds uttered in the mouth tube. As the plate revolves, the stylus and parts connected with it are carried forward toward the center of the disk, thus forming a spiral sinuous line in the wax film. When the record is complete, the stylus is removed and acid is admitted to the etching trough, from the bottle supported at the right of the machine. As soon as the plate is sufficiently etched, the trough is removed, the acid is returned to the bottle, the wax film is dissolved off, and the plate is transferred to the reproducing apparatus shown in Fig. 2.

In this apparatus the record plate is mounted on a vertical spindle and revolved as in the other case. The diaphragm of the reproducing instrument carries a stylus which follows the spiral groove in the plate, thus causing vibrations in the diaphragm similar to those produced by the sounds uttered in the mouth tube of the recording instrument. The diaphragm cell and reproducing stylus are carried upon the smaller end of the trumpet, which is delicately pivoted on a standard and counterbalanced so that the reproducing stylus exerts only a slight pressure upon the record plate. The volume of sound issuing from the trumpet is great. Instrumental and vocal music are faithfully reproduced. It is obvious that the records formed by this instrument are permanent, and the plates capable of being stored in a very small space.

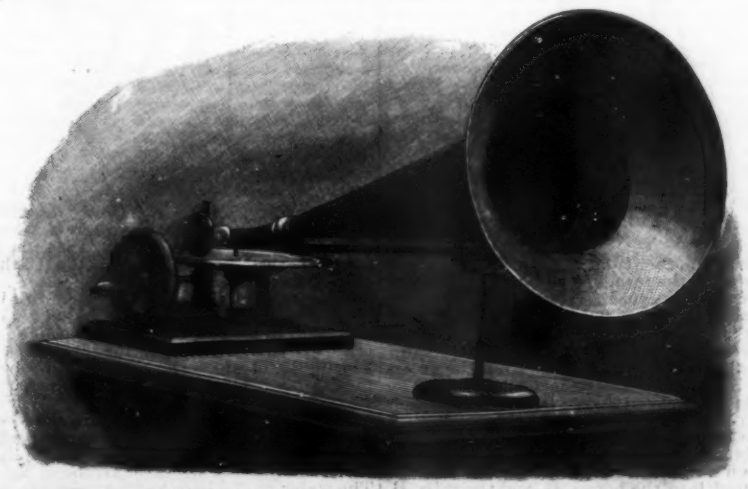


FIG. 2.—BERLINER'S GRAMOPHONE—THE REPRODUCER.

NEW METHOD OF EXTRACTING CUBE ROOT.

By Prof. H. A. WOOD, of the Stevens School.

CUBE root is a subject which has been so thoroughly investigated, and its modes of manipulation have become so fixed, that mathematicians may be disposed to meet with disfavor any innovation upon existing methods. It may seem difficult to devise for such a subject a new process which will meet with favor.

The ordinary methods of extracting cube root become long and tedious when the operation is extended to high numbers, or an approximation to several figures.

The following illustrates a simple method by which the root may be carried to many places with less labor than by any other process that has come to our notice. It might be called a method of finding several figures of the root at one operation, instead of repeating a special process for each figure of the root. If the number is a perfect power, containing twelve figures, or less, the principal work is reduced to a single division.

ILLUSTRATIVE EXAMPLE.

1. Extract the cube root of 1,412,467,848.

OPERATION.

$$11^3 = 121\,)\overline{1,412,467,848}$$
$$\underline{\quad 1167}$$
$$\underline{\quad\quad 28}$$
$$3\,)\overline{3367}$$
$$\underline{\quad 1122}, \text{ cube root.}$$

EXPLANATION.

In this example the cube root of the first two periods is readily found to be 11, which we take as the *trial* root. Dividing its square into the given power, to four terms, since the root contains four figures, we obtain the quotient 1167. To this quotient, adding twice the trial root, regarded as hundreds, and dividing by 3, gives 1122, the correct root.

Note 1.—If there is a remainder, after dividing by 3, it is disregarded.

2. The first term of the root is determined by inspection. The second term of the trial root, if not readily apparent, may be found by trial, or as the entire root is found above, when two figures are used for the trial root. The first two terms of the quotient must not differ by more than a unit or two from the trial root.

SOLUTION OF SECOND EXAMPLE.

$$15^3 = 225\,)\overline{3,341,362,375}$$
$$\underline{\quad 1485}$$
$$\underline{\quad\quad 30}$$
$$3\,)\overline{4485}$$
$$\underline{\quad 1495}, \text{ cube root.}$$

In this example, taking 14 for the trial root, the first two terms of the quotient being then 17, shows that 14 is too small. Taking 16 for the trial root, the quotient then being 13, shows that 16 is too great. By this means the second term of the trial root may be found, or the first two terms may be ascertained by the usual method of extracting cube root.

3. Required the cube root of 2515, correct to 7 decimals.

$$14^3 = 196\,)\overline{2515{\cdot}0}$$
$$\underline{\quad 12{\cdot}8}$$
$$\underline{\quad\quad 28}$$
$$3\,)\overline{40{\cdot}8}$$
$$\underline{\quad 13{\cdot}6}, \text{ 1st ap. root.}$$

$$13{\cdot}6^3 = 184{\cdot}96\,)\overline{2515{\cdot}00000}$$
$$\underline{\quad 13\,5975346}$$
$$\underline{\quad\quad 27\,2}$$
$$3\,)\overline{40{\cdot}7975346}$$
$$\underline{\quad 13{\cdot}5991782}, \text{ cube root, correct to nine figures.}$$

4. Required the cube root of 20. The nearest cube to 20 is 3^3.

$$3^3 = 9\,)\overline{20{\cdot}0}$$
$$\underline{\quad 2{\cdot}2}$$
$$\underline{\quad\quad 6}$$
$$3\,)\overline{8{\cdot}1}$$
$$\underline{\quad 2{\cdot}7} \text{ 1st T. R.}$$

$$2{\cdot}7^3 = 7{\cdot}29\,)\overline{20{\cdot}000}$$
$$\underline{\quad 2{\cdot}743}$$
$$\underline{\quad\quad 5{\cdot}4}$$
$$3\,)\overline{8{\cdot}143}$$
$$\underline{\quad 2{\cdot}714}, \text{ 1st ap. cube root.}$$

$$2{\cdot}714^3 = 7{\cdot}365796\,)\overline{20{\cdot}0000000}$$
$$\underline{\quad 2{\cdot}7152534}$$
$$\underline{\quad\quad 5{\cdot}428}$$
$$3\,)\overline{8{\cdot}1432534}$$
$$\underline{\quad 2{\cdot}7144178} \text{ 2d ap. cube root.}$$

From these examples we deduce the following

RULE.

I. Having separated the number into periods of three figures each, counting from the right, divide by the square of the *nearest* root of the first period, or first two periods; the *nearest* root is the *trial* root.

II. To the quotient obtained add twice the *trial* root, and divide by 3. This gives the root, or first approximation.

III. By using the first approximate root as a new trial root, and proceeding as before, a nearer approximation is obtained, which process may be repeated until the root has been extracted, or the approximation carried as far as desired.

Remark.—In example (4) it will be observed that the second term, or first two figures of the root, were obtained by using for trial root the root of the first period. Using, in like manner, these two terms for trial root, we obtained four terms of the root; and these four terms for trial root gave seven figures of the root correct. In that example the last figure should be 7. Should we take these eight figures for trial root, we should obtain at least fifteen figures of the root correct. In general, by carrying the division to twice the

number of places used in the division, the last figure will be correct, or but a unit or two out of the way.

That this method is a close approximation may be shown by algebra.

If a number is a perfect cube, the square of the cube root divided into the former will give the root. Suppose a number is represented by x^3. Let $x+1$ be the assumed root; then $x^3 \div (x+1)^2$ to two terms $= x-3$; adding twice the assumed root, we have $3x$, which, divided by 3, gives x. Take $x+2$ for assumed root, then $x^3 \div (x+2)^2 = x-4$, to two terms, to which add $2(x+2)$ gives, as before, $3x$.

Take 64, and assume the root to be $4-x$; then $64 \div (4-x)^2 = 4+2x+$ etc., to which add $2(4-x)$, and obtain 4 as the root. The smaller x is, the farther can the division be extended and yet give the true root.

In extracting the cube root of an algebraic expression, the first term of the root is obtained from the first term of the power, the second term of the root from the second term of the power, and so on, if the terms are arranged according to the powers of the letters; and as the divisor remains the same however great the number of terms, the work actually necessary may be made very brief. The extraction of the cube root of the following quantity contains all the work necessary:

$$x^6 - 6x^5 + 21x - 44x^3 + 63x^2 - 54x + 27 \mid x^2 - 2x + 3x^2$$

$$3x^4) -6x^5 + 21x^4$$
$$-6x^5 + 12x^4$$
$$3x^4) 9x^4$$
$$9x^4$$

The cube of $x^2 - 2x + 3$ gives the required power, therefore the root is correct. By the ordinary method the solution of such examples involves much labor.—*Stevens Indicator.*

MUSIC—TRANSPOSITION.

To the Editor of the Scientific American:

Transposition is one of the most beautiful studies to be found in music.

It is by no means difficult to understand. A few lessons in the art of transposing will make any pupil of ordinary musical ability an accomplished transposer.

The transposition of any tune half a tone higher or lower is the easiest part for the student. This is effected by merely a *change of signature*, and not by any change of notes.

Suppose we take any tune in the key of G (sig. one sharp), we may rub out the one sharp signature and put six flats. Where this has been done, we find that the same notes will answer.

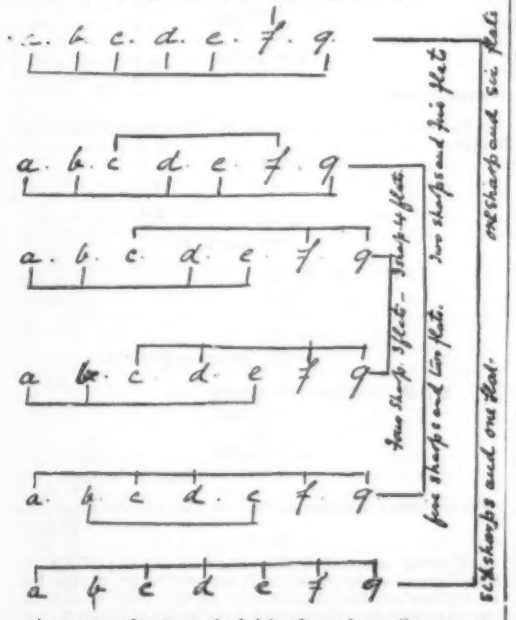
The following will be found a useful table for the young student:

TABLE.

Given Key.		Transposed Key.
1. One sharp	=	Six flats.
2. Two sharps	=	Five flats.
3. Six flats	=	One sharp.
4. Five flats	=	Two sharps.
5. One flat	=	Six sharps.
6. Two flats	=	Five sharps.
7. Six sharps	=	One flat.
8. Five sharps	=	Two flats.
9. Three sharps	=	Four flats.
10. Four sharps	=	Three flats.
11. Four flats	=	Three sharps.
12. Three flats	=	Four sharps.

N. B.—The above table refers to all tunes transposed half a degree. The sum of the sharps and flats in the given key and in the transposed key *must always be seven.*

The following will be found very useful:


a b c d e f g
one sharp and six flats
two sharps and five flats
three sharps and four flats
four sharps and three flats
five sharps and two flats
six sharps and one flat

As many of my musical friends and pupils are constant readers of your valuable paper, I trust you will publish this in some future issue.

ALFRED GRAINGER.

Wawanesa, Man.

COMPETITION BETWEEN THE LEBLANC AND THE SOLWAY SODA PROCESSES.

WHILE during the past year the production of soda by the ammonia (Solway's) process has attained colossal proportions, the economic conditions of the Leblanc soda factories is becoming continually more involved.

According to R. Hasenclever, the soda made by concerns which have adopted the Solway process represents on the total consumption the following percentages:

In Germany, 75 per cent.; in France, 60 per cent.; in Austria, 47 per cent.; in England, 22 per cent.

With the abandonment by many works of the Leblanc system the production of hydrochloric (muriatic) acid is diminished in consequence, and several industries that use large quantities of this acid complain of the increase in price. These include the manufacturers of bleaching compounds, of superphosphates, of gelatine extracted from bone, the galvanizers, etc. The low price of soda is a new difficulty for manufacturers of hydrochloric acid, because sulphate of soda, the residue produced in this industry, now is not in sufficient demand by glass makers, the carbonate being preferred in many cases.—*L'Industria.*

TANNING ANALYSIS.

METHODS AND APPARATUS IN USE AT THE LABORATORY OF THE BOURSE DE COMMERCE AT PARIS FOR THE ANALYSIS OF CERTAIN COMMERCIAL ORGANIC PRODUCTS.

By Dr. MUTER.

THE process adopted for the valuation of all sorts of tanning materials is the well known one which consists in ascertaining the amount of absorption taking place from a solution of the tanning material when brought into contact with prepared hide or with Seimand's ossein, the result being reported under the name of "available tannin." The arrangements for simplifying the process and rendering it sufficiently rapid to admit of its being done at the small commercial fees charged at the laboratory are (like most of M. Jean's arrangements) ingenious and effective. Before describing them in detail, it will be interesting to state that, disagreeing with the usual method of taking the specific gravity of the liquid before and after the maceration with the hide, M. Jean, for good and sufficient reasons, which he explained to us, considers it to be necessary to take the actual residue left on evaporation. The following is a short description of the process as actually in daily use:

1. *Extraction of the Crude Material and Preparation of the Solution for Analysis.*—The bark is ground in the mill, or dry extracts are pounded in the mortar, so that a powder is obtained which will pass through an ordinary "25" sieve. The quantity to be taken for analysis is, of oak bark, 25 to 30 grammes; of stronger things (such as chestnut wood), 20 to 25 grammes; while, of very rich extracts, it may only be needful to weigh 10 or 15 grammes. The quantity to be weighed is always to be judged by remembering that the solution, when actually made up to 250 c.c., must contain as nearly as possible 1 per cent. of "assimilable tannin." The sample, having been weighed, is now extracted by continuous percolation in a special apparatus. This consists of a cone of wire gauze, which is tinned or nickel-plated, and into which the weighed quantity of the sample is put. This gauze receptacle is then introduced into an outer tube, connected to an upright condenser, and to the foot of the tube is attached, by means of a cork, a flask of 150 c.c., capacity, having 100 c.c. of water placed therein. The water in the flask being boiled, continuous extraction takes place, which entirely exhausts any material within the space of one hour. In the Paris laboratory, where a large number of samples are being constantly dealt with, there are a series of condensing tubes, all passing through one large outer case of zinc, on which cold water streams, so that a whole row of extractions may be done at the same time. When the condensed liquid drops back into the flask perfectly colorless, the extraction is at an end, and the liquid is rinsed from the flask into a measure, and made up to 250 c.c. As a rule, this liquid is not perfectly clear, and seeing that it must be so before applying the powdered hide, we have next to proceed to:

2. *The Filtration of the Liquid.*—This is done by means of the apparatus shown in Fig. 1. A is a short

FIG. 1.

wide tube, having another tube, B, fused into its lower end, B being bent in the form of a siphon. To prepare A for use, a piece of wire gauze covered by flannel is first dropped in, and then that is followed by a pulp made by macerating filter paper in distilled water for a few minutes. When A is thus filled, the operator's lips are applied to the end of B, so as to suck out the excess of water and cause the pulp to mat together. The mouth of A is then closed by an India rubber cork, through which passes a bent tube, C, which is in turn attached by means of an India rubber tube, about 2 ft. long, to the bottom outlet of the bottle, D, this bottle being placed on a stand as shown. The liquid to be filtered is poured into the bottle, D, and the tube, B, is hooked over a receiving jar. The liquid now begins to filter, and the rapidity of filtration is regulated by altering the height of the bottle. The first 20 c.c. that pass through are rejected, and the remainder is used for the next step of the process.

3. *Extraction of the Tannin by the Powdered Hide.*—This is done in the apparatus shown in Fig. 2, and known as the "Tannimeter Jean." A is a glass tube,

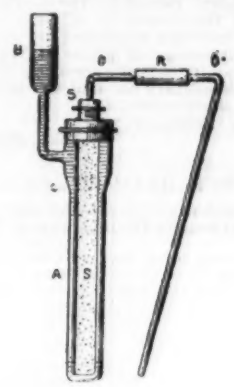


FIG. 2.

closed at the bottom, and having a cylindrical funnel and bent tube, B, fused into its upper part. Inside A an inner tube, S, is fixed by means of an India rubber ring. The tube, S, is in turn closed by an India rubber stopper, through which passes the bent tube, O. This tube is joined to a corresponding portion by means of a long cork, R, so that, when O is turned down, the whole forms a siphon with the inner tube, S. By turning O in R we can establish or stop the siphon action at pleasure. To prepare the apparatus for use we close the end of S with a piece of wire gauze covered with flannel, and we then pack it with the powdered hide, and place it in position inside A, as shown. The liquid to be exhausted is introduced into the funnel, B, *very slowly*, so that it is gradually sucked up into S by capillary action, the tube, O, being at the same time kept turned up to prevent any action of the siphon. When the liquid in the two tubes, A and S, have both reached the level of the point where the funnel tube is fused into A, some more of the liquid is poured into the funnel, B, so as to raise the level of liquid just short of the bend in O, and the whole allowed to stand for one hour. At the expiration of this time the funnel is nearly filled with the liquid, and the siphon having been turned down, filtration is established and continued until 40 c.c. have dropped from the longer limb of O. If the apparatus has worked properly, the filtrate should be limpid, almost colorless, and should not give a precipitate with gelatine. The powder used is the article produced at the Imperial Tannery in Vienna, and can be purchased with the apparatus from Demichel at Paris. When a new lot of powder is purchased, it is necessary to make a blank experiment by charging the "tanninneter" therewith, and using distilled water instead of a tannin solution, so as to obtain an extract. By now evaporating 25 c.c. of this liquid and weighing the residue, we obtain the check for the particular lot of hide powder. Such check is, however, very constant, and is 016 gramme for the ordinary powder containing 15·15 per cent. of moisture.

4. *Obtaining and Weighing the Residue.*—25 c.c. of the solution that has not passed through the tannimeter, and another 25 c.c. of that which has so passed, are each evaporated in a weighed flat-bottomed glass capsule at 212° F., and the dry residues are weighed. The difference between the two weights, less the check, gives the amount of "assimilable tannin," and this result multiplied by 10 gives the quantity in the weight taken for analysis, and, lastly, this is calculated to percentage. The apparatus actually employed for drying the residues is shown in Fig. 3. It works with

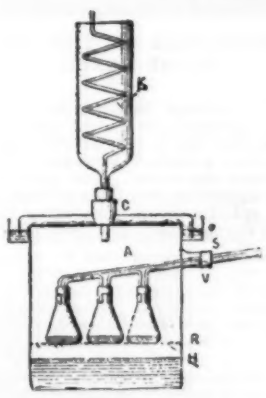


FIG. 3.

great rapidity, and is manifestly adapted to the obtaining of the residue of any fluid of which a number of samples are to be done at the same time. It is a copper bath, A, with a movable top, C, through which passes the end of an upright condenser. A trough containing sand goes all round the top of the bath, so that when the lid is put on, it fits steam tight. Water is put in up to the level, H, and immediately above there is a sheet of wire gauze, R, for the articles to stand on. The liquid, of which the residue is to be obtained, is placed in a tared flat-bottomed glass flask, the base of which is about 2·5 in. in diameter. When a series of flasks have been charged they are closed by India rubber corks, through which pass the arrangement of tubes shown in the drawing, such tubes projecting through a side tubulure, S, specially arranged for the purpose. The water in the bath having been set to boil, one of the glass tubes projecting through S is attached to an

empty flask, and this is in turn connected with a water vacuum pump. The whole of the flasks being immersed in vapor at 212°, and all the vapor being drawn off as fast as it forms, the evaporation proceeds with extreme rapidity. When no more liquid condenses at the extremity of the exhausting tube, the inlet tube is attached to an air-drying arrangement, so that a current of perfectly dry air is caused to pass over the residues, and the absolute desiccation is rapidly achieved.—*The Analyst.*

THE CHLORINE INDUSTRY.

AMONG the great chemical industries, the manufacture of chlorine is one that has been the object of a large number of tentatives during recent years. The Weldon-Pechiney process is the only new one that has entered into industrial practice. Although it cannot be asserted that it gives good results from a pecuniary point of view, since it has been applied for a short time only (about two years), the works that have already adopted the process appear to be satisfied with it.

The process is based upon the use of chloride of magnesium, and we shall now describe it to our readers. As well known, the principal inconvenience of the old method of preparing chlorine with binoxide of manganese and hydrochloric acid was that but half of the chlorine of the acid was obtained, the other half passing to the state of chloride of magnesium. We may represent the reaction that occurred by the following chemical formula:

MnO_2	+	2HCl	=	MnCl	+	2HO	+	Cl
Binoxide of manganese		Hydrochloric acid		Chloride of manganese		Water		Chlorine

Later on it was thought that this inconvenience had been overcome by the Deacon process, which consists in introducing hydrochloric acid mixed with air into a heater which raises it to 400°, and then into a decomposing apparatus containing a porous substance impregnated with a salt of copper. The acid reacts upon the latter and produces water, and the oxygen regenerates the primitive salt of copper and disengages chlorine. Unfortunately, the reactions do not take place thus in practice. They are never complete, so that by the Deacon process we obtain, at a maximum, but 60 per cent. of the chlorine of the acid employed, and, again, this rendering decreases in measure as the apparatus continue the longer in service.

The new Weldon-Pechiney process presents indisputable advantages over the preceding methods. In this mode of operating, Mr. Weldon treats the chloride of magnesium with magnesia, so as to obtain oxychloride of magnesium. This solid body is heated in a furnace with a current of air and is decomposed partly into free chlorine and partly into hydrochloric acid. The residuum consists of magnesia, which can be used anew in a subsequent operation.

It will be seen that this method requires the use of chloride of magnesium only, a product that can be cheaply obtained either by treating magnesia with hydrochloric acid, or getting it from sea water or Stassfurth salts, which constitute a residuum of little value, since the Stassfurth works in 1889 threw away about 200,000 tons; or, finally, it may be regenerated from the residua derived from the conversion of chlorate of magnesia into alkaline chlorates. Moreover, this process permits of obtaining the total amount of chlorine of the chloride of the magnesium. Per contra, this method necessitates the use of quite a large amount of fuel and a very costly plant. Yet, owing to the efforts of learned engineers, among whom may be mentioned Messrs. Pechiney and Boulouvard as standing in the first rank, these difficulties now seem to be happily surmounted.

We shall first study the Weldon-Pechiney process in the most complex case, that is to say, in supposing that the works are obliged to prepare their own chloride of magnesium. The other cases, as will be seen further along, are connected with this first mode of operating. The method comprises the following operations: 1, dissolving the magnesia in hydrochloric acid; 2, preparation of the oxychloride; 3, crushing and sifting of the oxychloride; 4, drying of the oxychloride; 5, decomposition of the oxychloride; 6, condensation of the hydrochloric acid.

1.—DISSOLVING THE MAGNESIUM.

The reaction is effected in a hexagonal lava vat provided with a mechanical agitator and surmounted with a hood communicating with the chimney of the works in order to carry off the acid vapors.

The agitator is set in operation, and hydrochloric acid, derived partly from the new and partly from the acid condensed in a previous treatment, is introduced into the vat. At the same time, there is added the calcined magnesia obtained as a residuum from a previous operation. Care is taken to add the magnesia and acid both gradually, in order to prevent too great an elevation of temperature and too great a production of vapor. With the magnesia, there is introduced into the vat the powder of the oxychlorides obtained by sifting, in the third operation, and that cannot be introduced into the furnaces.

The acid is kept in excess during the reaction, and when the apparatus is filled with liquid, it is saturated with magnesia, which precipitates the iron and alumina that may exist as impurities. There is also added a little chloride of calcium, which precipitates, under the form of sulphate of lime, the sulphuric acid that may be contained in the hydrochloric acid employed. The liquid is then transferred to depositing vats wherein the oxides and the sulphate of lime deposit. The limpid chloride of magnesium is decanted.

2.—PREPARATION OF THE OXYCHLORIDE.

In order that the oxychloride may form, the solution of chloride of magnesium must contain but six equivalents of water, in other words, it must correspond to the formula $MgCl + 6HO$.

In order to obtain it at this concentration, the solution is evaporated in boilers heated by direct contact with fire. It begins to boil at 115°, and when the point of ebullition has reached 140°, the heating is discontinued. The chloride thus brought to the desired concentration is introduced into a circular cast iron stirring apparatus, and then calcined magnesia derived from a previous operation is added.

Twenty-seven kilogrammes of magnesia to forty-eight of chloride are used. A large amount of heat is disengaged, the mass solidifies, and the agitators divide it into fragments. At the end of twenty minutes the operation is finished, and the oxychloride is removed and placed in heaps in cellars, where the reaction continues in consequence of the elevated temperature of the product.

3.—CRUSHING AND SIFTING THE OXYCHLORIDE.

The solidified oxychloride has been divided by the stirring apparatus into pieces of various sizes; it is necessary to reduce it to small fragments in order to facilitate the subsequent reactions. The cooled oxychloride is crushed between cylinders provided with diamond points, and the distance between which is so regulated as to obtain particles of the proper size. The product next passes into a bolting machine with five millimeter meshes. In this way is separated 20 per cent. of powder, which, as we have seen in the first operation, is mixed with the magnesia that is treated with hydrochloric acid.

4.—DESICCATION OF THE OXYCHLORIDE.

The oxychloride thus obtained would, were it calcined at a high temperature, give but little chlorine and much hydrochloric acid, on account of the large excess of water that it contains. It is therefore necessary to desiccate it before calcining it. We know, moreover, that it can be heated to 250° or 300° without disengaging notable quantities of hydrochloric acid. The desiccation is effected upon cars provided with superposed shelves. The oxychloride is placed on these in layers of from 5 to 6 centimeters in thickness. The cars, made up into a train, are run into a rectangular structure made of brick (Fig. 1) which is capable of holding ten of them. The hot gas coming from the decomposing apparatus (to be described further along) enters at a temperature of from 250° to 300°. The heating is methodical, that is to say, the cars move in a direction opposite that of the hot gas, the one that has just been loaded being near the place of exit of the gas, and the one that is about to be drawn out being near the place of entrance of the same. The drying chamber is provided at each extremity with a double door that permits of the entrance or exit of the cars without allowing the external air to enter.

During the desiccation, the oxychloride loses 60 per cent. of water and 6·6 per cent. of the total chlorine under the form of hydrochloric acid, the latter, moreover, being too dilute to be condensed.

5.—DECOMPOSITION OF THE OXYCHLORIDE.

In order that it may be decomposed simultaneously into hydrochloric acid and magnesia, the oxychloride must be heated to from 800 deg. to 1,000 deg. in a current of air that carries along the oxygen necessary to decompose the chlorides. The furnace in which this reaction is effected forms the principal feature of the manufacture. The apparatus consists of two stationary furnaces heated by a movable burner. These furnaces (Fig. 2) are rectangular, and are constructed of refractory bricks, and covered with iron plate and with iron bands, to prevent expansion. Each furnace is provided with three apertures; one at A, at the top, for the charging with oxychloride, another at B, for the introduction of the hot gases, and a third, C, at the bottom, for the elimination of the products of combustion and the residual magnesium.

The burner consists of cast iron tubes, T, inclosed in a strongly hooped iron plate jacket lined with bricks The tubes are rectangular, and are divided by vertical partitions into three compartments. The central ones conduct the combustible gases derived from the Siemens gas generators and the others lead the air necessary for combustion, and which enters directly under the burner through the apertures, *o o'*. This burner can be shifted from one furnace to the other by making it run upon rails.

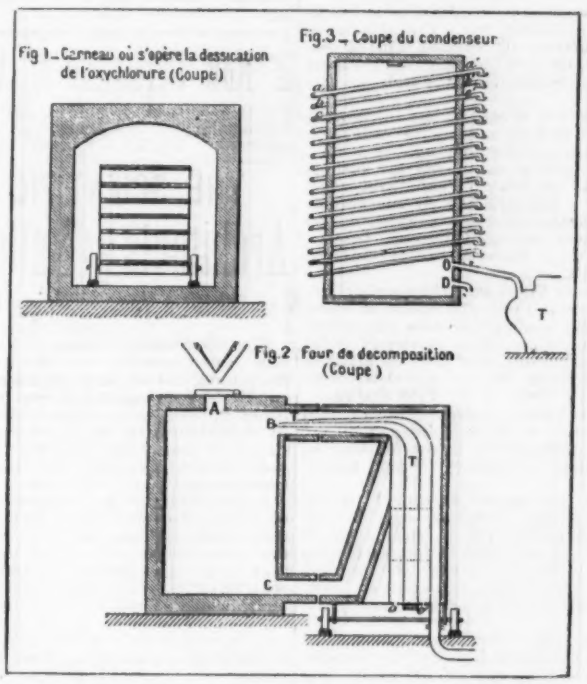
The fifth operation comprises two parts—the heating of the furnaces and setting them in operation.

The heating is effected by bringing the burner in front of the furnace to be heated. The mixture of gas and air enters the furnace through the aperture, B, and is ignited in a vacant space—the combustion chamber. The gaseous products formed are eliminated through the aperture, C, and, as may be seen in the figure, pass into the burner around the tubes that lead the air and gas, and give up to these latter a portion of their caloric. Thence the waste heat goes, as has been said, to heat the chamber in which the desiccation of the oxychloride is effected.

When the desired temperature is reached in the furnace, that is to say, after four or five hours, the burner is removed and placed before the other furnace. The first furnace is next set to work. The upper aperture, B, is closed, though not hermetically, by a vertical door in such a way that the air necessary for the decomposition may enter through the chinks. The lower door, C, is closed hermetically. It is mounted upon a hollow axis through which the gases contained in the furnace are sucked. The oxychloride is put into the furnace through the trap, A. The decomposition begins at once by reason of the high temperature of the furnace, and lasts for four or five hours. The mixture of chlorine, hydrochloric acid and steam that the furnace contains is sucked through the hollow axis of the lower door, as has been seen. In the sixth operation we shall see how this suction is brought about.

6.—CONDENSATION OF THE HYDROCHLORIC ACID.

The gases on making their exit from the furnace have a temperature of 300° or 400°. They are cooled by making them pass into a square lava condenser (Fig. 3) traversed by numerous inclined glass tubes, *aa'*, *bb'*, *cc'*, etc., cooled internally by a current of water. The hot gases enter at the top of the condenser and make their exit at the bottom at O. A portion of the hydrochloric acid is condensed and is collected at the bottom of the condenser, whence it flows out through the orifice, D. The gases afterward traverse a series of flasks, 80 in number (the first of which is seen at T), wherein the condensation of the hydrochloric acid is finished. The remaining gases then flow to an exhauster, which effects the suction that we have spoken of above. This pneumatic apparatus consists of a system of leaden bells that rise and descend alternately over a bath of chloride of calcium, which does not dissolve the chlorine. The latter, on making its exit from the apparatus, may be used for preparing bleaching chlorides (chloride of lime, Javelle water, etc.), according to the usual method, or else may be employed for the production of the chlorates that we shall examine further along.



APPARATUS FOR THE MANUFACTURE OF CHLORINE BY THE WELDON-PECHINEY PROCESS.

FIG. 1.—Section of desiccating chamber. FIG. 2.—Section of decomposing furnace. FIG. 3.—Section of condenser.

Since the establishment of this process at the Salindres works, Mr. Pechiney has introduced the following modification into one of the apparatus for decomposing the oxychloride. In the arrangement already described, the furnaces are stationary and the burner is movable. In the new system the arrangement is just the reverse. The furnaces are placed back to back and mounted upon a turntable. We have thus only to move the burner backward or forward and cause the furnaces to revolve. Finally other works have adopted another and equally ingenious process: the two furnaces are stationary and placed opposite each other, and the burner is placed in the center upon a turntable. When one of the furnaces is sufficiently hot, the burner is revolved 180° in order to heat the other furnace. The object of these modifications is to do away with the somewhat complicated maneuvering attending the shifting of the burner, the advantage thus gained being of considerable importance where it is a question of an apparatus weighing about thirty tons.

In the exploitation of the Weldon-Pechiney process, instead of manufacturing one's own chloride of magnesium, the natural chloride of magnesium of sea water or of Stassfurth salts may be used. This natural chloride would be employed exactly as is the artificial chloride in the preceding case.

7.—MANUFACTURE OF CHLORATES.

At the Salindres works, the chlorine obtained as we have described is made to act upon magnesia in suspension in water in the proportions of 50 to 100 grammes per liter. The reaction takes place in apparatus

in the form of churns and provided with mechanical agitators.

A mixture of chlorate and chloride of magnesium is formed. The liquor is decanted and concentrated to 48° Baume, and allowed to crystallize. The crystalline mass obtained, which consists principally of chloride of magnesium, is turbined. The liquor that flows off consists for the most part of chlorate of magnesia. The chloride of magnesium that it still contains is precipitated by the addition of magnesia in the state of oxychloride insoluble in the solution of chlorate. Upon turbining a second time a purified liquor of chlorate of magnesia is obtained. To this, chloride of potassium is added, when a double decomposition takes place that gives chlorate of potash and chloride of magnesium. The liquid is concentrated to 40° Baume. The chlorate of potash crystallizes, the mother water is drained off, and the chlorate is then refined in order to be put upon the market.

The mother water, which contains chloride of magnesium mostly, is evaporated. The residual chloride may be used for the production of chlorine, as we have said.—*La Nature.*

THE SULPHURING OF DRIED FRUIT.

By Prof. HILGARD, of the California Experimental Station.

THE question whether sulphuring of dried fruit is a harmful practice or not continues to be a bone of contention.

This sulphuring of dried fruit has two chief objects. One, and that most generally kept in view, is the brightening of the color, which always darkens, particularly in sliced fruit, in whatever way it may be dried, the change of color being due to the action of the air upon certain easily changeable substances contained in all fruits. This darkening is a practically inevitable result of drying any fruit in contact with air, whether in sunshine or by artificial heat, and should be looked for by every consumer, as the natural mark of an honest, unmanipulated article.

The second object sought to be attained by sulphuring is to render the fruit secure from the attacks of insects, whether by rendering its surface unpalatable before the eggs are laid, or by killing eggs laid during sundrying that might subsequently hatch in the packages.

The latter object involves, of course, the sulphuring of the dried fruit; the former is to a greater or less extent attained by sulphuring before drying.

When freshly sliced fruit is sulphured for a short time, the gas penetrates only "skin deep," and when the fruit is afterward dried, whether in the sun or drier, most of the gas escapes, and few persons would note the difference in taste produced thereby. Insects, nevertheless, are to a very material extent deterred from touching such fruit.

But when the latter is dried and thoroughly sulphured, as is too commonly done, the effect is much more serious. The gas then penetrates the entire spongy mass, bleaching it, so that carelessly dried fruit, too dark to be marketable, can thus be made to appear more or less inviting to the eye—not, however, to the nostrils or to the taste, for with the color, the flavor has also suffered correspondingly; and upon opening a package of such fruit, instead of the natural aroma, there appears the flavor familiar to those who visit a chemical laboratory or acid manufactory.

The consumer then has reason to object to dry sulphured fruit on two counts, either of which is sufficient to condemn the practice. One is that dirty, ill prepared or damaged fruit may thus be imposed upon him for good quality; the other, that the natural flavor of the fruit is either seriously impaired or sometimes completely destroyed, and its acidity greatly increased.

There is another and very serious count in the indictment, namely, that such fruit is unhealthy because containing an antiseptic that impedes digestion, and while the fruit is relatively fresh, causes headaches just as will sulphured wine. After some time, the "sulphurous" acid originally introduced becomes converted into "sulphuric" acid, a condiment that few will desire to consume in their daily food. The sulphuric acid contained in the unsulphured fruit is present in the form of "neutral salts," such as occur in the ash of all vegetable products, while that which is added in sulphuring exists in the form of free acid.

In apricots the increase of sulphuric acid was to the extent of about twice and a half the amount originally present, although these were reported to have been sulphured only before (more probably during) drying. Their lack of natural flavor and pungent acid taste at once revealed the effects of sulphuring.

In prunes which had been sulphured after drying, the effect was much more striking. Here the increase was to over six times the natural contents. The total amount added by sulphuring amounted to nearly a third of one per cent., and the free sulphuric acid in the dried fruit amounts to 22 per cent., which is about 25 grains of commercial oil of vitriol per pound.

In addition to rendering the fruit unpalatably acid, it had been rendered obnoxious both to the digestive organs and to the teeth. No one could habitually consume such fruit without feeling the effects of such an amount of mineral acid, introduced into his food purely for the gratification of the eye with an unnatural tint.

But so long as the public, and its agents, the dealers, continue willing to pay from 30 to 50 per cent. more for the whitened sepulchers offered them in the shape of sulphured fruit than for that which retains, with its natural tint of dried fruit, and with it the marks of careful or careless treatment, so long will the producer continue to supply the demand for the doctored article, unless, indeed, the law should intervene, as has been done in most European countries. There the sale of sulphured fruit is simply forbidden as injurious to public health, and as coming under suspicion of having been doctored up from an inferior article with fraudulent intent.

I think the time has come to make a step forward and try to put upon the market a first class article of "unsulphured dried fruit," with the express statement and claim that it is unsulphured and retains the natural sweetness and flavor of California fruit, instead of being reduced to a common level with the worst products of any other country. For it is certain that the whitish green dried apples and pears now sold at high prices in our grocery stores might just as well have been grown anywhere from Norway to the Mediterranean, for aught they teach of the quality of our fruits.

The following suggestions are offered to those who are willing to practice sulphuring to a moderate degree only and with some regard to the conservation of the fruits' palatableness:

Large quantities of sulphur introduced at once into the drier or sulphuring box will tend to cause a deposit of sulphur, in substance, on the outside of the fruit, adding its flavor to that of the acid, which alone is useful. The less sulphur is put in at one time, and the more air admitted, the less there will be of the visible fumes that carry the sulphur up into the fruit. It is best to let the sulphur catch fire all over before putting it into the box at all.

Let whatever sulphuring you must do be done before drying, as in that case not only will the drying process itself drive off a great deal of the superfluous acid and prevent it from penetrating the whole, but the flavor of the interior will penetrate outward and measurably do away with the laboratory odor that will otherwise pervade the fruit package.

A very sightly and appetizing cinnamon brown tint for sliced apples and pears may be secured by dipping for a few minutes the freshly made slices, contained in a properly shaped basket (of galvanized wire if desired), into a solution of salt containing not less than two ounces in five gallons of water. This prevents any spotting where the fruit has been touched. Instead of the salt, a similar solution of the bisulphites of soda or lime may be used, which effect a slight external bleaching without injury to the flavor of the fruit.

Last, but not least, let us try to gradually educate the public taste up to the point of preferring in this matter the substance to the shadow, and accepting healthy, brown, high flavored dried fruit to the sickly tinted, chemical tainted product of the sulphur box.

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TABLE OF CONTENTS.

PAGE

I. BIOLOGY.—The Role of the Microbe.—By A. R. SMART.—Some difficulties in the germ theory of diseases described, and the limits of the applicability of bacterial investigation of the present day.. 12241

II. CHEMISTRY.—Tanning Analysis.—By Dr. BUTER.—The commercial analysis of bark and extracts as conducted in Paris.—3 illustrations 12244

III. CIVIL ENGINEERING.—Paris Central Pneumatic Power Stations.—An exhaust air system of distributing power.—2 illustrations..... 12235

The Belleville Cable Railway.—A cable railway recently constructed in Paris.—Full particulars of its construction.—3 illustrations..... 12231

The Sault Ste. Marie Canal.—The connecting link between Lake Superior and Lake Huron.—Its international importance.—1 illustration..... 12231

IV. ELECTRICITY.—Connecting Lightning Conductors to Gas and Water Pipes.—A plea in favor of the old construction of lightning conductors, in face of the researches of Prof. Lodge..... 12236

Electrolysis of Different Substances.—By P. L. ASLANOGLOU.—Some simple experiments in electrolysis described.—3 illustrations 12237

The Electrolysis of Metallic Phosphates in Acid Solution.—By EDGAR F. SMITH.—An interesting research in electro-chemistry.. 12236

V. MATHEMATICS.—New Method of Extracting Cube Root.—By Prof. H. A. WOOD.—A very simplified method of extracting the cube root for use in arithmetic and algebra..... 12243

VI. MEDICAL AND HYGIENE.—Improved Ophthalmic Refractometer.—An apparatus for determining the exact condition of the human eye as regards its powers of vision.—5 illustrations..... 12240

Medicinal Soaps.—Leading medicinal soaps now on the market and their qualities..... 12240

Seborrhœa and Baldness.—An annoying disease affecting the hair, and its treatment 12241

VII. MUSIC.—Music Transposition.—An interesting letter on the subject of transposition of airs..... 12244

VIII. NAVAL ENGINEERING.—The Amiral Baudin.—Particulars of this formidable ship, one type of a first class French ironclad.—5 illustrations 12234

IX. GUNNERY AND ORDNANCE.—Fabrication of Twelve Inch Mortars.—By A. A. FULLER and F. M. CONNET.—Elaborate description of the manufacture of heavy mortars in America.—3 illustrations..... 12232

X. PHOTOGRAPHY.—Magic Photographs.—The mysterious photograph.—A few interesting examples of magic photography.—4 illustrations..... 12236

XI. PHYSICS.—An Improved Wave Apparatus.—By JOHN T. STODDARD.—An ingenious apparatus for illustrating the combination of two simple sound waves.—2 illustrations..... 12242

Color and Coloring.—By Prof. A. H. CHURCH.—The first of a series of lectures on color giving the most advanced views and theories.—1 illustration..... 12237

The Gramophone.—A talking machine involving a different principle than that utilized in the phonograph.—4 illustrations..... 12243

XII. TECHNOLOGY.—Competition between the Leblanc and the Solway Soda Processes.—The great increase in the adoption of the Solway soda process in Europe..... 12244

Everyday Work in the Rubber Factory.—Practical notes on rubber moulds and on white and colored rubber..... 12234

The Chlorine Industry.—A new process for making chlorine by the utilization of oxychloride of magnesia.—3 illustrations..... 12245

The Sulphuring of Dried Fruit.—By Prof. HILGARD.—The advantages and disadvantages of treating dried fruit with sulphurous acid..... 12246

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